Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

JULY, 1911.

PLANT HAIRS.

By K. E. STYAN.

(Continued from Page 166.)

III.—BRANCHED AND STINGING HAIRS.

(*a*) THE term "compound" is applied to branched hairs, their distinctive feature being that they give off lateral branches from the main pedicel instead of from the tip, as do *forked* hairs.

Among the branched hairs are all kinds of most extraordinary-looking structures, and many of very great loveliness.

If we examine a hair from the leaf-sheath of garden *Ribes* (see Figure 1) we find that the main pedicel is more or less thick all its length, and distinctly swollen at the base, glandular-tipped, and ornamented with numerous lateral branches, which are long and very slender, giving the appearance of a person holding up many arms. Again, in the Deadly Nightshade (see Figure 2), a most strange form of branched hair may be found, consisting of a number of thick, clumsy-looking cells, fitting into each other at all sorts of awkward angles, which create an impression of a hand with fingers pointed out and down, or of some species of thickly-formed coral from a foreign sea. Every part of this plant—the stem, leaf-surfaces, veins, flower stems, calyx and corolla surfaces, corolla tube, stamens and stigma—

FIGURE 1.
Hair from the leaf of Garden *Ribes*.

FIGURE 2.
Hair from the corolla tube of Deadly Nightshade.

FIGURE 3.
Hair from the leaf of the Chili Nettle (*Loasa*).

show these marvellous little hairs, and they are indeed "things" worth looking at very carefully. Figure 3 depicts two hairs from the leaf of the Chili Nettle. On this plant two distinct forms of hairs are found: (1) these branched ones and (2) others of quite different form, that sting. No one can deny that the branched hairs are very formidable looking structures, with their barbs, or tiny, sharp-pointed branches springing out at all angles from the surface of the chief pedicel, which is swollen at the base. A hair like this reminds one rather of the teeth of the sword-fish. Figure 4, illustrating a hair from the leaf of the wild Mouse-ear Hawkweed, shows another branched hair, somewhat similar to that of the Chili Nettle (*Loasa*), but different in that its apex divides off into two wee branches, and its lateral ones are thicker and less tooth-like.

FIGURE 4.
Hair from leaf of Mouse-ear Hawkweed.

Perhaps *Stinging* Hairs should be included amongst the glandular, since they secrete a peculiar acrid burning fluid, but they are so interesting that this fact seems to warrant their being considered by themselves.

Two species of stinging plants have been chosen by way of illustration (1) the Chili Nettle (see Figure 6), (2) the Common Stinging Nettle (see Figure 5).

Our own Stinging Nettle (*Urtica*) receives its name from the burning property it possesses, "*Urtica*" being derived from "*uro*" I burn. An individual hair of this plant shows a very enlarged bulbous base composed of a large number of elastic cells, a long pedicel, and an oval, slightly enlarged, sharp-pointed "cap" at the tip. The cells at the hair-base contain the gland that secretes the acrid fluid. By means of a duct that runs up the pedicel, this fluid is conducted to the tip of the hair, and, if the point of the delicate cap be broken or pressed against unwarily, the sharp point pierces the flesh and the secreted fluid is injected. If, however, the hair be damaged *below* the cap, no uncomfortable feeling is experienced because the stinging fluid does not then become injected into one's skin.

Our own English species of Stinging Nettles are unpleasant enough to handle roughly, but some of the foreign species, especially *Urtica baccifera* and *U. Balerica* are most formidable plants. In some of the East Indian species they are truly dangerous for, after the first pricking sensation has passed away, it is often followed by that of hot irons being rubbed on the flesh, and the pain increases to such an extent that, after hours and sometimes days, the patient is seized with symptoms like those following influenza and lock-jaw, whilst sometimes death results—especially when the stinging has been caused by one species of nettle from Java. Our own species never prove in any way dangerous, merely discomforting at the time and sometimes for several hours afterwards. Another plant—*Malpighia urens*—has dangerous stinging appendages, and they are met with also in some species of *Rhus*.

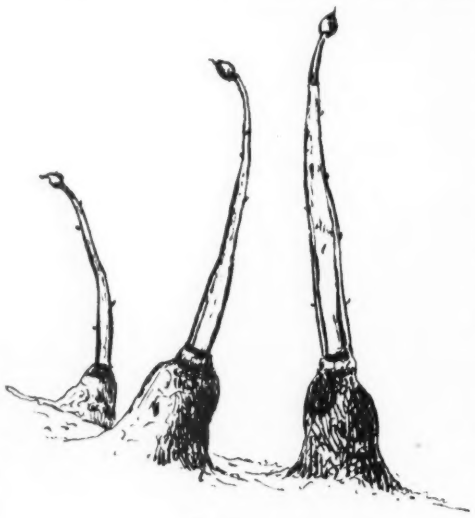

FIGURE 5.
Stinging hair from the leaf of Wild Nettle.

An individual hair of the Chili Nettle (*Loasa*) is bulbous at the base and there secretes its acrid fluid which runs up the pedicel duct to the hair tip. In this case, however, unlike our own nettle, the tip is not swollen into a distinct "cap" but is very sharp-pointed, like a curved needle. These hairs grow in thick masses, along with those that are branched, on the leaves and stems of the plant. In both cases the hairs are probably defensive.

FIGURE 6.
Stinging hair from the leaf of the Chili Nettle.

THE GOLDSCHMIDT REACTION.

By H. STANLEY REDGROVE, B.Sc. (Lond.), F.C.S.

1. Scientific Aspects of the Goldschmidt Reaction.

It was in 1898 that Dr. Hans Goldschmidt announced that he had succeeded in reducing the oxides of many metals very conveniently by the aid of aluminium[1]. That aluminium should prove a most powerful reducing agent, readily reacting with the oxides of other metals with the production of much heat, is a result that might very well be expected from the fact that aluminium has a greater heat of combustion, and therefore possesses a greater affinity for oxygen than the majority of other metals. But like certain other substances which, capable of reacting exothermically (*i.e.*, with the evolution of heat) with one another, will not do so until a certain amount of energy has been supplied to them from without, aluminium and metallic oxides will react with one another only at high temperatures. Earlier attempts, however, to bring about the reduction of metallic oxides by aluminium, by heating mixtures of these ingredients, proved very unsatisfactory; for either no reaction took place, not sufficient heat to start it being supplied, or else it occurred with explosive violence. Dr. Goldschmidt overcame the difficulty by an ingenious device. He found that intimate mixtures of metallic oxides and powdered or granulated aluminium, if heated strongly at one point, react with the production of intense heat, the temperature produced being far greater than that required to initiate the reaction. Consequently the reaction spreads throughout the whole mass, as a matter of fact doing so very rapidly, the time of reaction, which is about half to one minute in the case of iron oxide and aluminium, not appreciably depending upon the quantity of material employed.

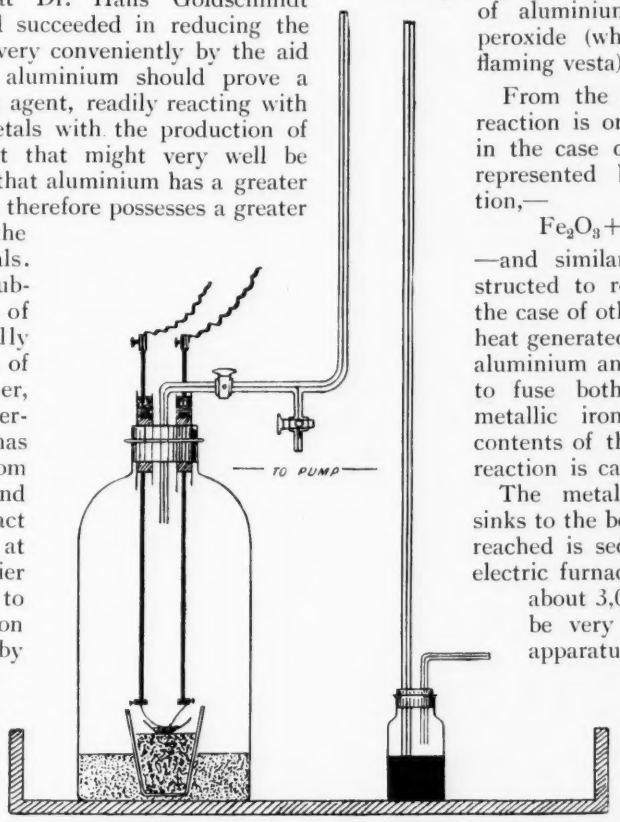

Figure 1.

Apparatus employed by Weston and Ellis for carrying out "thermitic" reactions *in vacuo*.

The external heating necessary to start the reaction may in some cases be supplied by means of a strip of burning magnesium; or better, a fuse composed of aluminium powder and barium peroxide (which can be ignited by a flaming vesta) may be employed.

From the chemical standpoint the reaction is one of the simplest, thus, in the case of *iron* oxide it may be represented by the following equation,—

$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe,$$

—and similar equations can be constructed to represent the reactions in the case of other metallic oxides. The heat generated in the reaction between aluminium and iron oxide is sufficient to fuse both the alumina and the metallic iron produced, the whole contents of the crucible in which the reaction is carried out becoming fluid. The metal, owing to its density, sinks to the bottom. The temperature reached is second only to that of the electric furnace, being estimated to be about 3,000°C. The reaction can be very readily carried out, no apparatus beyond a crucible of highly refractory material being required. Care, however, should be taken to protect the crucible in case it should be cracked by the heat of the reaction, and its molten contents run out.

That substances apparently so inert as aluminium and iron oxide should be capable, once interaction between them has been started, of producing sufficient heat, not only to continue their own combustion, but to liquefy iron and even more difficultly fusible metals, may seem an extraordinary fact. But it is quite analogous to the behaviour of a rock nicely balanced at the top of a hill. Leave it alone, and what could seem more destitute of energy; give it but a gentle push—and who shall stay its course?

By using other oxides in place of iron oxide

[1] H. Goldschmidt: "Ueber ein neues Verfahren zur Darstellung von Metallen und Legirungen mittelst Aluminiums" *Annalen der Chemie*, (1898), Vol. 301., pp. 19 *et seq.*, and H. Goldschmidt and C. Vautin: "Aluminium as a Heating and Reducing Agent" *Journal of the Society of Chemical Industry*, (1898), Vol. 17, pp. 543, 649.

Goldschmidt was able to prepare many other metals (in a fused condition). Moreover, providing that the oxide was present in slight excess of the amount chemically equivalent to the quantity of aluminium employed, the corresponding metal was obtained in a state of exceptional purity, free from carbon. By using mixtures of oxides, alloys of desired composition were similarly obtained. It seems, indeed, that practically all metallic oxides will react in this manner with aluminium. In some cases, *e.g.*, titanium and vanadium, in which pure metals are not obtained, the product is sufficiently pure for the preparation of the chlorides. Even calcium oxide (lime) is not entirely proof against the activity of aluminium, though the reaction between these two bodies can only be brought about when they are heated together in a furnace, and is then by no means complete. It seems, therefore, to differ from the reactions between aluminium and other metallic oxides in being endothermic (*i.e.*, heat-absorbing), and it may be concluded that calcium has a greater heat of combustion than aluminium (measured, of course, with respect to the same quantity of oxygen).* Magnesia, however, is quite unattackable by this most active element. With alumina itself, aluminium yields a blackish-grey product, probably containing a sub-oxide.

Aluminium reacts in a similar manner with the sulphides of the metals. Thus, with galena (lead sulphide) the products are lead and aluminium sulphide, as shown by the following equation,—

$$3PbS+2Al=Al_2S_3+3Pb.$$

This reaction may be employed for the preparation of aluminium sulphide (which cannot be obtained in the wet way, since it is decomposed by water, giving aluminium hydroxide and sulphuretted hydrogen) which is obtained pure if the aluminum is present in slight excess.† This excess of aluminium also serves to free the lead from any metallic impurities, for whilst aluminium will not alloy with lead, it readily alloys with many other metals. If aluminium were cheaper, the method might be used commercially for the extraction of traces of the precious metals from lead ores.

Aluminium will also react with certain non-metallic oxides (*e.g.* boron trioxide and silica). In the former case the product of the reaction contains aluminium boride and aluminium nitride (the nitrogen coming from the air) as well as alumina and free boron.‡ In the latter case impure silicon is obtained as a crystalline substance containing aluminium. Aluminium will also react with charcoal; in this reaction the air seems to play an important part, the product containing aluminium oxide and nitride, as well as aluminium carbide (Al_4C_3) together with unchanged aluminium and carbon.§

Since Goldschmidt's discovery, many other reactions, similar to those between aluminium and metallic oxides, in which substances other than aluminium are employed, have been described. Dr. F. M. Perkin, for example, has succeeded in bringing about the reduction of metallic oxides and certain other substances (*e.g.*, galena and borax) by means of metallic calcium.‖ Dr. Goldschmidt has also carried out experiments with this metal; he finds that it reacts with oxides in a most violent manner, but a regulus of metal is not formed owing to the limited fusibility of the calcium oxide produced. He finds, also, that, whilst silicon alone yields unsatisfactory results, a mixture of calcium and silicon reacts with metallic oxides in a satisfactory manner, giving a fusible slag of calcium silicate.¶

Another substance, behaving in a similar manner, is calcium hydride (CaH_2). Dr. F. M. Perkin finds that a mixture of this substance and cupric oxide (in the proportion of two molecules of the oxide to one of the hydride) can be readily ignited; volumes of steam are evolved and copper is produced, but the temperature is insufficient to melt the whole of the copper. A mixture of antimony sulphide and calcium hydride is also very easy to ignite. As the reaction proceeds, the mixture swells up in a manner similar to that in which mercury thiocyanate ("Pharaoh's serpents") behaves when heated.**

Messrs. F. E. Weston and H. R. Ellis have carried out a series of experiments on "thermitic reactions" (as these reactions are called) *in vacuo*. Their final form of apparatus is shown in Figure 1. They found considerable difficulty in igniting the mixtures experimented upon, but this was probably due to the difficulty of producing a sufficiently high temperature *in vacuo*. They succeeded, however, in obtaining reaction *in vacuo* between magnesium and sodium peroxide and between aluminium and sodium peroxide by ignition with a platinum wire electrically

* F. E. Weston and H. R. Ellis: "The Heats of Combustion of Aluminium, Calcium and Magnesium," *Transactions of the Faraday Society*, (1908), Vol. IV., pp. 130 *et seq.*

† In this reaction the mixture may be heated in a crucible furnace with the cover off; but the aluminium should not be too finely powdered, as otherwise the heat generated may be sufficient to volatilize the lead, giving rise to an explosion.

‡ F. E. Weston and H. R. Ellis: "Note on the Action of Aluminium Powder on Silica and Boric Anhydride," *Transactions of the Faraday Society*, (1907), Vol. III., pp. 170 *et seq.*

§ F. E. Weston and H. R. Ellis: "The Interaction of Aluminium Powder and Carbon," *Transactions of the Faraday Society*, (1908), Vol. IV., pp. 60 *et seq.*

‖ F. M. Perkin: "Reduction of Oxides, Sulphides, &c., by Metallic Calcium," *Transactions of the Faraday Society* (1907), Vol. III., pp. 115 *et seq.*

¶ English Patents, 788, Jan. 11th, 1906.

** F. M. Perkin and L. Pratt: "Reducing Action of Metallic Calcium and Calcium Hydride upon Metallic Oxides, Sulphides and Halogen Salts," *Transactions of the Faraday Society* (1907), Vol. III., pp. 179 *et seq.*

heated; and by the use of the latter mixture as a fuse they succeeded in obtaining reaction *in vacuo* between aluminium and iron oxide. In air, one drop

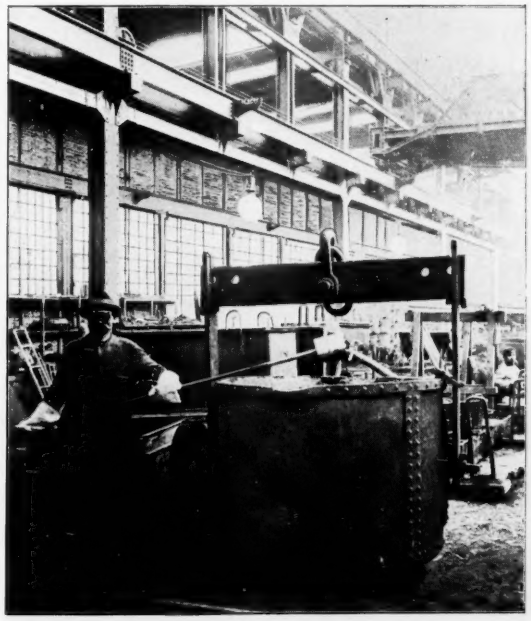

FIGURE 2.

Titanium "thermit" in foundry work.
(Heating "thermit" tin over the ladle before insertion.)

of water added to a mixture of aluminium and sodium peroxide causes it to react; but *in vacuo* they found it to cause merely a slight effervescence.*

II.—TECHNOLOGICAL ASPECTS OF THE GOLDSCHMIDT REACTION.†

The technological importance of Goldschmidt's reaction can hardly be over-estimated. The whole subject is as yet in its infancy, but already it may be said to constitute a new branch of technology, to which the name of "Alumino-thermics" has been given.

In the first place, the reaction serves for the preparation of a number of pure metals and alloys of considerable value in the iron and steel and allied industries. Of the former of these we may mention chromium (98–99% pure), manganese (96%), and molybdenum (98–99%). Chromium is used in the manufacture of high-speed tool steel, as well as armour plate: manganese is also used in the manufacture of very hard steel. Amongst the alloys we may mention chromium-manganese, manganese-titanium, ferro-titanium, ferro-vanadium and ferro-boron.

"Thermit"‡ containing a small amount of titanium oxide is used in foundry work. The mixture, placed in a tin fastened to an iron rod (see Figure 2), is plunged into the molten iron as soon as it is run from the furnace into the ladle, and held at the bottom until the reaction is over. The slag rises to the top and can be removed. It is found that this treatment tends to prevent blowholes and to give clean, dense castings, the effect of the titanium being to increase the fluidity of the metal and produce a finer grain; moreover, the sulphur content is decreased.

In the slag from the reaction of chromium "thermit," minute rubies are found, ruby being nothing but crystallised alumina coloured with chromium; but they are too small to be of any commercial value. A use, however, for the slag has been found. Dr. Buchner has discovered that, owing to its comparative freedom from metallic impurities and absolutely anhydrous condition, it is preferable to natural corundum (which it resembles) in the manufacture of pottery, for which purpose it is mixed with clay and burned, and is especially useful for making chemical apparatus which may be subjected to great changes in temperature without fracturing.

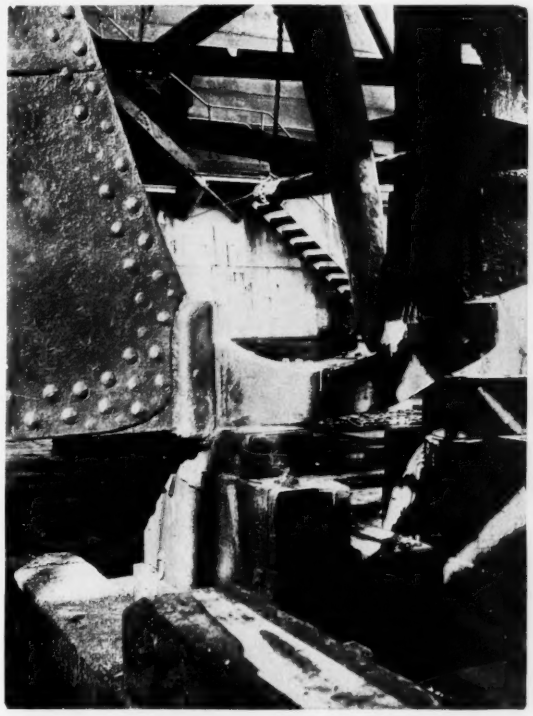

FIGURE 3.

Alumino-thermic repair to the stern frame of the s.s. "Sevilla" after twelve months.

* F. E. Weston and H. R. Ellis: "Thermic Reactions in Vacuo," *Transactions of the Faraday Society*, (1910), Vol. VI.

† The writer's heartiest thanks are due to "Thermit, Limited" for their kindness in supplying him with full information concerning the technological applications of Goldschmidt's Reaction, for opportunity to examine their apparatus and methods, and for the loan of the blocks of several illustrations in the present article.

‡ "Thermit" is the registered name given to a mixture of aluminium and iron oxide.

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"Thermit" is also employed technologically as a heating agent. As Dr. Goldschmidt has pointed out,* in "thermit" we have a new sort of fire differing in certain respects from all other fires. In the first place, in the combustion of "thermit" neither is air consumed nor is any gas evolved, as in the case of the combustion of such substances as wood, coal, coal-gas or petrol. The second difference is in the heat density. The actual amount of heat obtainable from a given weight of "thermit" is really much less than that obtainable by the combustion of the same weight of anthracite; but in the former case the whole of this heat is, so to speak, obtained at once, the reaction between large quantities of iron oxide and aluminium, as we have already indicated, occupying a very short period of time; indeed, by the combustion of "thermit" a heat density is produced unattainable otherwise. It is these peculiarities in its behaviour which determine the applicability of the "thermit" fire. Where a continuous heating effect rather than density of heat is the essential desideratum, "thermit" would be useless; thus it is not suitable as a source of heat for locomotive purposes or for cooking generally. But where great density of heat is required, "thermit" is preferable to other forms of fire, because by its aid one can so readily produce an enormous temperature at a moment's notice.

One of its chief applications as a heating agent purely is in the butt-welding of iron pipes. The ends of the pipes to be welded together are surrounded by a suitable mould, into which the products of the "thermit" reaction are poured. Welding temperature being reached, the ends of the pipes are pressed together by means of screws arranged in position beforehand. Of course, if the liquid iron produced in the reaction were allowed to come into contact with the pipes, they would be burnt through, but it is found, as a matter of fact, that the highly-refractory alumina slag, which issues from the crucible first on pouring out its contents after the reaction, solidifies on the surfaces of the pipes, thus forming a protective coating which is impenetrable by the molten metal.

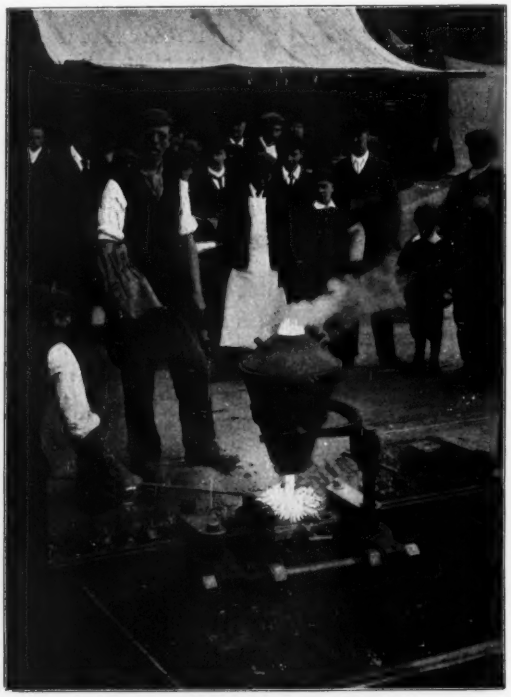

FIGURE 4.
Alumino-thermic welding of tram rails.

In a method of welding which has been chiefly applied in the welding of tram lines, not only is the heat derived from the "thermit" re-action utilised to heat the lines to welding point, but the liquid steel produced is employed to form a bulb of metal holding the two lines together, thereby strengthening the joint. An illustration of the method in use is shown in Figure 4. The "thermit" is ignited in a crucible with a hole in the bottom fitted with a device for tapping. The moulds around the rails are constructed in such a manner that the "thermit" steel, which first issues from the crucible when it is tapped after the re-action is over, runs to the bottom, forming a metal bulb over the joint to about

FIGURE 5.
Alumino-thermic welding of "third" rails (Paris, Metropolitan Railway).

* H. Goldschmidt: "Alumino-Thermics," *Transactions of the American Electrochemical Society* (1904), Vol. VI, Part II, pp. 85 *et seq.*

half way up the rail or more. The metal, of course, must not be allowed to come in contact with the top of the rail. The molten alumina, which flows out of the crucible after the liquid metal, completely covers the top of the joint, and welding temperature being reached, the rails are pressed together by screws placed in position beforehand.*

It is interesting to know that tests carried out on rails thus welded have proved very satisfactory. The following are given by the Manchester Corporation Tramways (November 29th, 1906).

BENDING TESTS.

	Span.	Loads Elastic Limit.	Bending Moment.
Solid Rail	10 Feet	28,200	70,500
Fishplate Jointed Rail ...	10 „	10,000	25,000
Thermit Jointed Rail ...	10 „	25,000	62,500
Solid Rail	5 „	74,000	92,500
Thermit Jointed Rail ...	6 „	42,000	63,000

HARDNESS TESTS†.

Load on Die in Tons.	Welded Rail. Length of Indentation Produced.	
	Away from Joint.	Close to Joint.
0·25... ...	... 0·26 Inch	0·26 Inch
0·50... ...	... 0·32 „	0·32 „
0·75... ...	... 0·37 „	0·36 „

It is clear from the hardness test that the subjection of the welded edges of the rails to the high temperature of the "thermit" reaction products has no injurious effect upon the hardness of the rail.

A somewhat similar method to the above is employed in welding third rails on electric railways (see Figure 5).

The liquid steel produced by the "thermit" reaction may be employed in all sorts of repairs to iron and steel articles; and not only is it applicable to small articles but to work on the largest scale. Indeed, by the ignition of a couple of hundredweights of "thermit" one may produce in a few moments a hundredweight of super-heated mild steel, a quantity producible in so short a period of time by no other means. In repair work it is often found advantageous to add a certain proportion of steel punchings to the "thermit": this reduces the quantity required and renders the reaction less violent. As an illustration of the applicability of "thermit" to marine repairs we reproduce a photograph (Figure 3) of a repair to a fracture (20-in. by 8-in.) in the stern frame of s. s. "Sevilla" of the Hamburg-American Line, taken after twelve months use.

[We are indebted to Messrs. Thermit, Limited, for the loan of Figures 2 to 5.—EDS.]

* English Patents, No. 10,859, May 25th, 1901. (Dr. Hans Goldschmidt: "A new and improved process for welding metals.")

† These tests were made by measuring the lengths of indentations made by a hardened steel die with a curved edge struck to a radius of one inch, and having a cutting edge whose angle was 50°.

UNIQUE AMERICAN STEAM MOTOR CAR.

By FRANK C. PERKINS.

DURING the past decade the steam motor car has been developed to a high state of perfection in Europe, and has entered the field of urban and inter-urban service with the gasoline motor car, in competition with electrically operated motor cars. In the United States, however, little has been done in this line until recently.

The accompanying illustration shows a new and unique car as utilized for passenger service, provided with a baggage compartment and seats for thirty-eight passengers.

Although this steam motor car was not designed for freight service, its capacity for hauling trailers or freight cars in an emergency has been demonstrated by hauling a train of freight cars, weighing fifty-two thousand pounds.

The car has a total length of thirty-seven feet three inches with a width of nine feet two inches, and it weighs complete, without passengers, sixty-six thousand pounds. There is included in this weight, six thousand six hundred pounds for water and oil, the latter being utilized as a fuel instead of coal. It is maintained that this American steam motor car is capable of developing a speed of forty miles per hour on a level track and is designed for hauling not more than two trail cars or two express or freight cars under normal conditions, although in emergency longer trains can be handled.

FIGURE 1.
An Unique American Steam Motor Car.

It may be stated that the engines are hung to the motor trunk but the car body carries the water tube boiler which supplies steam to the driving cylinders at a pressure of 200 pounds per square inch.

The engines develop one hundred and twenty-five horse-power and are capable of driving the car at a speed of forty miles per hour, with two hundred pounds steam pressure and on a level track. It is maintained that the use of crude oil for making steam is most convenient in operation and cleanly, there being no dust nor dirt as when coal is used and the combustion in the fire box is complete.

While the primary object aimed at, it is said, in the development of this design was to provide a self-contained steam motor car for passenger service, still considerable freight and express may be handled when necessary, and a number of trailers may be hauled during heavy passenger service on extra occasions when required.

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FIGURE 1.
Gold Medal of the Royal Astronomical Society of London.

THE POLITICAL IMPORTANCE OF ASTRONOMY AS A PEACE PROMOTER.

By IRENE E. TOYE WARNER.

Member of the British Astronomical Association and of the Société Astronomique de France.

THERE have been numerous conferences recently to consider how best to promote international arbitration and peace.

The study of geography and history on a wider scale has been suggested, but the vast and *living* power of astronomy in this matter has, as far as I can learn, been practically overlooked. It is to this subject, therefore, that I wish to draw special attention in this article.

Astronomy is pre-eminently a living thing, ever growing, changing, and advancing — requiring united and universal study. More and more as time goes on we find a tendency towards coöperation amongst astronomers throughout the whole world. Racial and party differences are at least buried, if not wholly forgotten, in the study of a science which deals with other worlds and universes, and draws our thoughts from all that is earthly, to consider that which is heavenly.

From its very nature, and the conditions necessary for its favourable study, it is peculiarly fitted to play a most potent part in the promotion of universal peace. Religion and commerce are generally acknowledged to be the two greatest civilizers of the world, but experience has shown that, in the present state of the world's evolution, neither has quite succeeded in banishing war.

FIGURE 2.
Bronze Comet Medal of the United States of America.

I do not for a moment claim that where they have failed, astronomy would succeed, but I maintain that the latter must become a great bond of union between those very nations at present divided by both religion and commercial interests. This is largely due to the fact that astronomy can never become a means of money-

making or an object of greed. No one will ever be able to claim the stars as an exclusive possession. On the other hand there is no tendency towards socialism, for does not "one star differ from another star in glory"? and do not all the planets obey their ruler, the Sun?

Should not all who "consider the heavens" learn that in them is universal peace as a result of universal law and order?

There is nothing that binds races or nationalities together, promotes comprehension, and fosters friendly rivalry, like having a common object of

FIGURE 3.
Janssen Medal of the Société Astronomique de France.

individual we honour the nation to which he belongs, and promote a kindly feeling between the winner and donor of the gift.

Other nations win our medals and rewards, and we, in our turn, receive theirs, the only qualification necessary being sterling worth.

Then, in the matter of *work*, hearty and effective coöperation is no longer a dream but a reality, amongst the students of the heavenly science, for it is an actual *fact* that in the pursuit of astronomical research and observation, all nations, peoples, and

FIGURE 4.
One of the Medals of the Société Astronomique de France.

interest which appeals only to the highest emotions without exciting the baser passions of mankind—and such, undoubtedly, is astronomy.

I do not think it is generally known that all astronomical honours and rewards are distributed according to merit, irrespective of nationality. For example, the Gold Medal of the Royal Astronomical Society is given to astronomers of *all* nations and creeds, and tongues, so long as their merit is established by the work they have done. And in thus honouring the

FIGURE 5.
The Valz Medal of Paris.

languages are united.

Eclipse expeditions are ever a means of fostering amity between astronomers of different nationalities, particularly when the eclipse happens to be visible from some desert island where the various members of the party are thrown much together!

There is an International Congress on the "Map of the Sky," held at Paris. This congress is composed of seventy leading astronomers, representing twenty-two countries, scattered all over the globe. These "peace-promoters" meet to

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report the progress made in the preparation of an enormous photographic atlas of the heavens, which was begun in 1887 and will not be finished for another ten years. On this map over forty million stars will be marked, and when complete it will represent the combined work of astronomers of nations otherwise divided by race, creed, and commercial interests.

Comets are ever a means of promoting peace amongst widely separated nationalities. A good example is furnished by the "hairy star" discovered by Mr. Morehouse, of America. This comet in its course passed almost from the North to the South Pole, and exhibited many variations in form and brilliancy. It was seen and photographed by astronomers at nearly all the observatories in the world and thus a complete record of the history of this beautiful object was obtained by the *united* efforts of the students of the heavenly science.

FIGURE 6.
Commemorative Medal of the Société Astronomique de France.

In its journey past this "little sun-lighted wanderer in the depths of the Infinite"—as one of our greatest living poets terms the Earth:—it saw many sad sights. Fierce rivalry and doctrinal quarrelling amongst the various sects, each crying "I am of Paul! . . . I of Apollos! . . . I of Cephas!" and only a small minority who actually "live" Christ. To quote the same sweet singer (Mr. S. R. Lysaght)

"We are faithless of life, and in *creeds* our unfaith do we hide; the world that our faith should unite with our creeds we divide."

It saw political war, each party fighting for power and proclaiming an immediate Utopia if they gain it; and the universal struggle, and keen competition of commerce; yet quiet, and apart from all the turmoil of life, it found a devoted band of astronomers whom no differences of creed, nationality or interest could deter from coöperation in studying its gauzy, fairy-like self!

Surely, then, if we teach the nations even the elementary truths of this great science and give them a common and united interest in the starry realms, we lift their thoughts heavenward and appeal to those higher emotions in the human soul, which ever make for *peace*. Let all, then, who love science unite in striving to teach its many lessons to the inhabitants of Earth, so that in the fulness of time those that are "afar off" may draw near in unity, peace and concord.

SPRING AND SUMMER SHOOTING STARS.

By W. F. DENNING, F.R.A.S.

I OBSERVED seventy-eight meteors in May, during watches extending over twenty-two-and-a-half hours in the aggregate.

Very fortunately, this year one of the meteors was seen by Mr. Fiammetta Wilson, at Reigate, and by myself at Bristol, on May 24th. Details are given at the end of this note, and I also give the real path of a bright long meteor, recorded by the same observers from the radiant at 350°+37° on May 29th. This shower is a remarkable one from the exceptional swiftness of its meteors in September. The radiant being a long way from the earth's apex in that month, we should expect only slow flights from it, but I have recorded them as *very swift*.

May meteors are very rarely abundant, but I found them unduly plentiful on the 24th this year. Clouds veiled the stars in the early evening, but a west wind cleared the sky at about 10.15 p.m., and the stars afterwards shone with a splendour not often equalled at this time of the year. I saw eighteen shooting stars in one-and-a-quarter hours.

July may be regarded as the advent of the meteoric observer's prolific season. This month always exhibits a great increase in the frequency of meteoric phenomena. At the middle of the month the earth may be said to emerge from the region of scarcity which she has been traversing since the middle of December to enter a space far more richly occupied with these tiny planetoids which illumine our skies in the form of shooting stars. The first fortnight of July usually gives few meteors, but Perseids actively during the last week. An observer may sometimes count twenty or twenty-five meteors per hour and more than three times the number ordinarily visible in the spring months of the year.

It is to be hoped that, as the heavens will now for some time present such an abundance of meteors, many observers will specially watch for them and record details of all the brighter objects. It is important this work should be performed for the purpose of securing duplicate observations, of the same objects, at two stations. Without these data it is often difficult to ascribe the correct radiant points and the real paths cannot be determined.

REAL PATHS OF TWO METEORS OBSERVED AT REIGATE AND BRISTOL.

Date	May 24 ...	May 29
G.M.T.	$10^h\ 38^m$ ...	$10^h\ 42^m$
Radiant	243° + 34° ...	350° + 37°
Mag. of Meteor ...	3 − 2 ...	3 − 1
Height at First ...	72 Miles ...	74 Miles
Height at End ...	53 „ ...	57 „
Length of Flight ...	20 „ ...	91 „
Velocity per Second...	35 „ ...	30 „
Position over—		
Beginning	6 Miles N. of Southampton	E. of Northampton
Ending	4 Miles N.E. of Netley	Salisbury
Name of Meteor ...	ξ Coronid ...	ι Andromedid

AN ANTEDILUVIAN ZOÖLOGICAL GARDEN.

By DR. ALFRED GRADENWITZ.

THOUGH no human fancy could imagine the infinite variety of forms embodied in the representatives of the animal and vegetable kingdoms—either of which is known to number hundreds of thousands of different species—an even superficial glance at the fossil remains of extinct organisms shows that Nature in the course of bygone ages has brought forth many startling forms to which no analogy is to be found in our present vegetation or fauna.

FIGURE 1. *Stegosaurus* assailed by *Ceratosaurus.*

Carl Hagenbeck, the founder of the famous animal park at Stellingen, near Hamburg, where even the most savage beasts are kept in a state of apparent freedom, has installed in his Garden of Eden a series of wonderfully life-like representations of the most striking monsters that inhabited our earth in prehistoric times, thus creating what may be called an Antediluvian Zoölogical Garden. These weird giants, who millions of years ago ruled this world of ours, can be seen in surroundings corresponding to their very modes of life, thus producing a perfect illustration of what the earth looked like in their days. In fact, an hour spent in that strangest of all sceneries brings us back as in a dream to a world which the science of palaeontology allows us to reconstitute in its very details.

In that long-distant past the struggle for life among the animal dwellers on earth must have been much more acute than even now. A perpetual war was waged between those monsters, startling alike by their form and enormous size. The manifold natural weapons which Nature had lavished upon them proved no sufficient protection in the course of time, the more so as the changing climatic conditions sealed their final doom to extinction. Apart from such features as are entailed by the peculiar conditions of their antediluvian world, these animals certainly have much in common with existing species, their remote descendants, and strikingly illustrate the slow evolution from one class to another, with many intermediate stages between reptile and bird, fish and mammal, and so on.

These antediluvian cement models, made in artistic perfection by the well-known animal sculptor, Mr. J. Pallenberg, have been arranged in an impressive group

FIGURE 2. *Allosaurus* feeding on the remains of a *Brontosaurus.*

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round the shores of a beautiful little lake encompassed by abundant vegetation. Most of them are seen standing by the water's edge amidst the shrubs and trees, while huge crocodiles and weird creatures emerge from the lake itself. Scenes of battle between these monsters of bygone ages lend additional realism to their appearance.

Every care was taken to investigate most conscientiously all the bone finds and fossil imprints housed in the foremost museums of the world, especially the American Museum of Natural History. Each model was submitted to the leading authorities in the science of palaeontology who, wherever necessary, suggested such alterations as might produce a perfect agreement with scientific data.

A fascinating scene of battle offers itself to the observer's eye as he reaches the bridge crossing the lake (see Figure 1). A monster called *Ceratosaurus* which could be described as a crocodile with huge kangaroo-like hind-legs and tail, is seen assailing another beast of the reptile class, the *Stegosaurus* which, though protected by a double row of plates or spines up to a yard in length down the centre of its back, and by spikes upon its tail, is likely to have been too clumsy in the long run to resist the attacks of its more agile, though considerably smaller, enemy.

FIGURE 3. *Iguanodon.*

A short way off is seen an even much larger giant, called *Brontosaurus* (see Figure 2) who has already succumbed in the struggle for life.

An *Allosaurus*, likewise a huge lizard of the same family of monsters, is gluttonously devouring the remains of his luckless herbivorous fellow, who apparently was quite unfitted for any serious struggle. The triumphant dinosaur with its huge head and large pointed teeth — as evidenced by the circumstances under which its remains have been found — was one of the rulers of those times, and thanks to its enormous fore-claws, so well adapted for lacerating, its powerful long hind-legs, so admirably suited for jumping, was excellently fitted to play a domineering part. The dinosaurs, generally speaking, constituted a family of land-dwelling

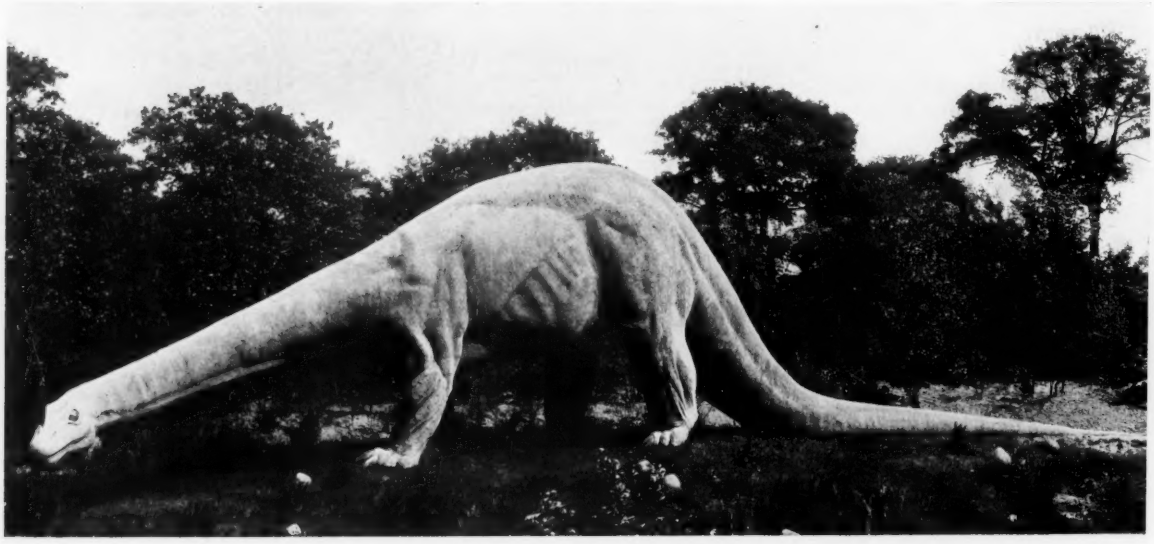

FIGURE 4. *Diplodocus carnegiei.*

reptiles with an astounding abundance of forms which are the more remarkable as the structure of their skeletons gives evidence of a continuous transition to the bird class of animals.

One of the largest among these monsters, beside which the surrounding trees look small indeed, is a giant *Iguanodon* (see Figure 3), the head of which towers some twenty-five feet above the ground. This weird creature habitually walked on its bird-like hind legs as proved by the enormous foot-prints up to thirty inches in length and forty-five feet apart which have been found in the weald of Sussex. The erect position and bird-like gait of this beast was assisted by the extreme bulk of its tail: the neck was relatively long, the arms short and the first and fifth fingers stood out nearly at a right angle to the three middle fingers. However, the head was surprisingly small and this limited provision of brain obviously failed to protect the *Iguanodon* in its struggle for life.

Another dinosaur species, the *Diplodocus* (see Figure 4) bears a certain resemblance to the former, but is of even huger dimensions. This animal lived in Wyoming, Montana, Colorado, New Mexico and the Dakotas, which countries then possessed a tropical climate and included extensive lakes of salt water, the sedimentary remains of which form the "bad lands" of our day. The *Diplodocus*, sixty-six feet in length, at the Stellingen Park, has been reconstituted from the most complete and not from the largest bone finds of its kind. This mammoth lizard possessed a tail even longer than the *Iguanodon*, while the hind-legs were not much longer than the fore-legs, thus enabling the beast to use all four limbs for walking about. The enormous length of the neck and remarkable smallness of the head are equally striking.

FIGURE 5. Rhinoceros Saurians.

Between the place where the *Iguanodon* stands, and that reserved for its fellow, the *Diplodocus*, visitors can watch a charming idyll of ten million years ago (see Figure 5). A family of "rhinoceros Saurians" (*Triceratops*) has come to the lake, and the father lustily disports himself in the water from which only his head and shoulders are seen to emerge, while the mother with her little one still lingers at the water's edge. Apart from the thick lizard tail, characterising them as reptiles, these strange animals strikingly remind us in general appearance of the rhinoceros of our day. The *Triceratops* had three horns, a beak like a bird of prey,

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and a broad-toothed frill surrounding its neck.

An even more ancient group of fossil lizards comprises the *Plesiosaurus* (see Figure 6), which could be

FIGURE 6. *Plesiosaurus.*

described as an enormous seal with long, thickened tail, remarkably long neck and a tiny head. It was a marine reptile with limbs reminiscent of whale fins, with five toes and no claws. A somewhat related family comprises the fish-like Ichthyosauria which among the reptiles of their age occupied a similar position to the whales among present-day mammals. Their neck was short and stumpy, their snout remarkably large, the tail lengthy and vigorous, and the limbs as short as whale fins. Such an *Ichthyosaurus* is seen (see Figure 5), in the lake to emerge from the water with the swift and elegant motion of a first-class swimmer, allowing the head, the front half of the back and the rear fin to be seen.

Like these whale-shaped reptiles, the fossil flying lizards or Pterosauria have left no representative among the reptiles of our day. In fact, the only analogy in our present-day fauna could be found with the bat family of the mammal class. However, while the flying membrane of bats extends between the second, third, fourth and fifth fingers and the body, that of the Pterosauria reached from the strikingly developed last (fourth) finger to the body. The first three fingers were short and fitted with claws. A number of these strange beasts are seen in the Stellingen Park, squatted at the water's edge, crawling on the rocky shore, or resting on its stone slabs. These bird-lizards comprise a few *Aerosaurus* with their broad snouts and some *Rhamphorhynchus* with long rat-like tails. On a mighty rock towards which the *Diplodocus* is taking its course there are represented two giant flying dragons in a lazy creeping position and with striking life-likeness (see Figure 7). These Pteranodons, as they are called in science, were huge, short-tailed flying lizards endowed with a long marabou beak and a narrow crest of nearly equal length at the back of their head.

Simultaneously with the now extinct animal families, there lived many other species which are more or less closely related to the reptiles of the present day. Some specimens of these are the big and small crested lizards (*Dimetrodon* and *Naosaurus*) represented in Figure 9. While resembling in their outward appearance an alligator endowed with an especially large and broad snout, they were characterised by a high crest with rigid spikes running alongside their back.

Two real crocodiles from the Cretaceous and Jurassic formations, which are mainly distinguished from present-day representatives of the same family by their clumsy build, are shown half hidden in the water (see Figure 9). On the turf are seen creeping two huge turtles characterised by a cartilaginous formation on the tail and head, and especially by two large horn-like excrescences near the ear.

In addition to antediluvian reptiles, there are

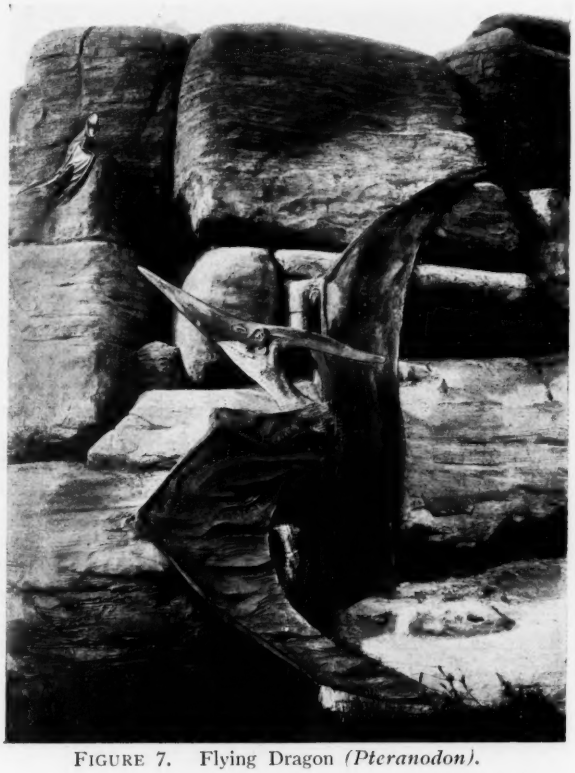

FIGURE 7. Flying Dragon (*Pteranodon*).

found some fossil animals belonging to other classes. Quite a number of primitive birds (*Archaeopteryx*) (see Figure 8), which are still closely related to the

reptile class, are seen roosting here and there on the rocks and at the water's edge. The birds are characterised by a long tail, consisting of vertebrae, to which the large steering feathers are fastened in a row on either side. The wing comprises three well-developed fingers, while some real bevelled teeth are still found at the edges of the jaws. Remains and imprints of *Archaeopteryx* have been unearthed at Solenhof, Germany, in the lithographic slate of the Jura formation. From the middle of the lake is seen to emerge the mighty head of a batrachian, called *Mastodonsaurus*, which was a member of a family common to the coal and trias formations. While the largest amphibia of our day hardly reach one-and-a-half meters length, these antediluvian ancestors of theirs comprised some species, whose skull alone measured one-and-a-half meters in length. Another amphibian is the *Pareiosaurus*, about two meters in length, seen half-hidden in the shrub, which can be described as a giant toad endowed with a short, blunt tail, and a head relatively narrower and less flattened than that of present-day toads, the skin showing striking remains of bony armour plates.

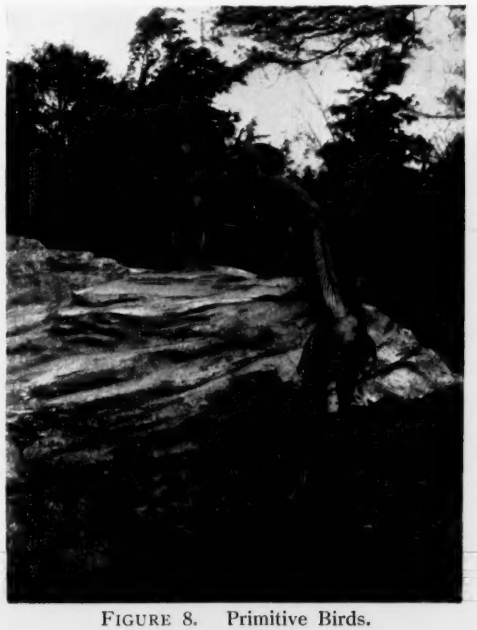

FIGURE 8. Primitive Birds.

Even a fossil insect, viz., a giant dragon-fly of upwards of 2 feet wing expanse, is represented at the Stellingen Park (see Figure 9).

Elaborate plans have been made for extending this antediluvian "Zoo" by the addition of a number of new specimens belonging to all the known extinct animal families.

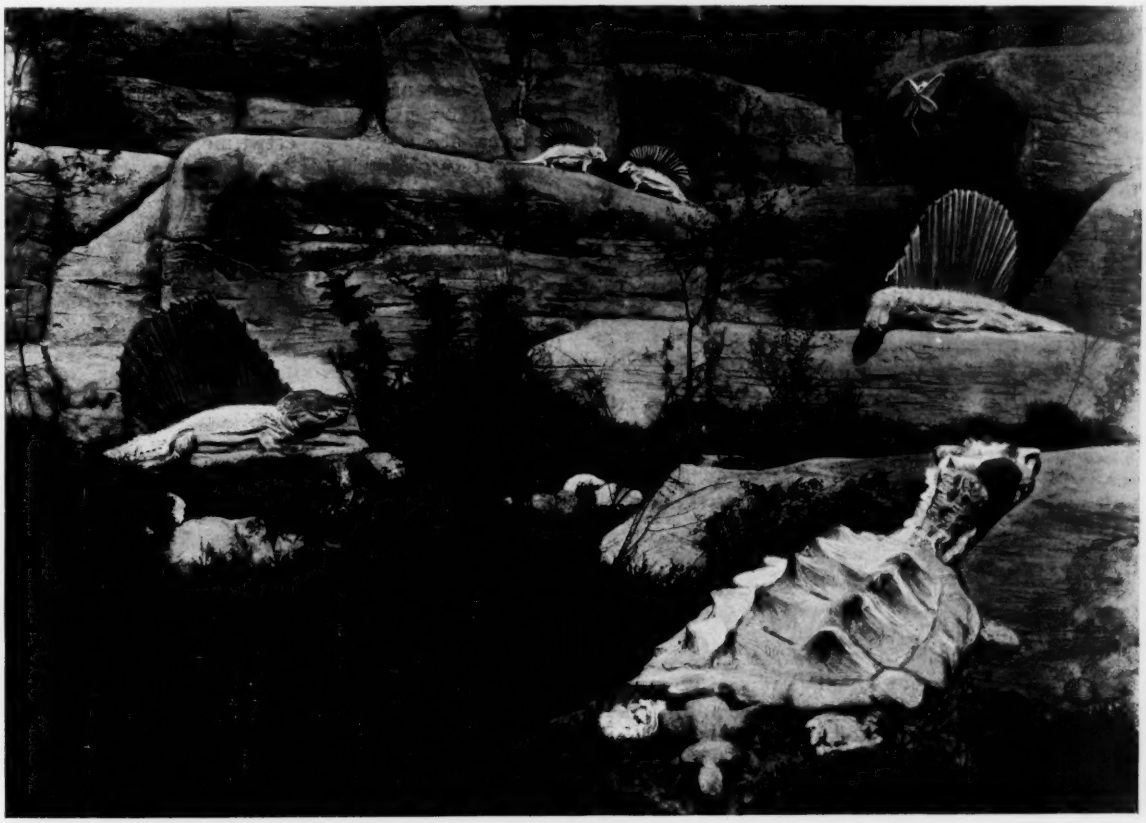

FIGURE 9. A collection of Antediluvian Reptiles.

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RADIO-ACTIVE RECOIL.

By WALTER MAKOWER, M.A., D.Sc.

It is well known that when a shot is fired from a cannon, the latter attempts to move backwards and is said to recoil. Furthermore, if the cannon is free to move, then its velocity is such as to make the momentum of the cannon equal to that of the shot which causes it to recoil. The momentum of a body is a quantity which may be taken as giving a measure of the quantity of motion in a system and is measured by the product of the mass and velocity of the body considered.

The question whether the ordinary laws of dynamics apply to the case of atoms as well as to that of molecular masses has frequently been discussed, but till recently it has been beyond the possibility of direct experiment to test the point. By the recent discoveries in radio-activity the motion of streams of atoms, and in some cases of single atoms, can be observed and studied and the possibility has thus been afforded of investigating the dynamics of atoms in motion. It is now generally accepted that radio-active processes are the manifestations of changes in the constitution of the atoms concerned, and are of a more subtle nature than chemical changes, in which atoms of various kinds react on each other without affecting the internal structure of the atoms themselves. Thus to take as an example the case of the best known radio-active substance—radium, discovered by Mme Curie. It is now certain that this element, which is similar to barium in its chemical behaviour, is slowly but constantly ejecting positively charged atoms known as α particles which have been shown by Rutherford and others to be nothing other than charged atoms of helium. This can be proved by collecting the α particles, which can be detected in many ways and then subjecting them to spectroscopic analysis. The remainder of the atom from which the helium has been expelled constitutes a new element also displaying radio-active properties, which happens to be a gas, and is called the *emanation*—a name which has persisted since the time of its discovery, when its nature was not yet fully understood. The emanation, whose chemical and physical properties are entirely distinct from those of the radium which produced it, in turn gives off α particles, and disintegrates into a new product which has been called radium A. The only essential difference between this change and that undergone by the radium exists in the difference in the speed of the disintegration. Whereas radium takes thousands of years to change into the emanation and helium, the emanation is much more unstable, and disappears in the course of a few weeks. A similar process occurs with radium A, which in turn gives rise to a series of successive radio-active products, known as radium B, radium C, and so on. It should here be mentioned that all radio-active processes are not exactly of the nature just described; for in some cases the disintegration is associated merely with the expulsion of an electron—that minute negatively charged particle first detected by J. J. Thomson. It will, however, be sufficient for present purposes to confine attention to those transformations in which the radio-active change is associated with the expulsion of an α particle, which we have seen is a charged atom of helium.

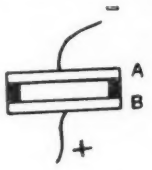

FIGURE 1.

The change of radium A into radium B, mentioned above, presents a particularly convenient case for studying the phenomena of atomic recoil; for radium A has a very short "life," and quickly disappears with the production of radium B, an α particle being ejected during the process. The details of the method of obtaining pure radium A from the emanation need not be considered here; suffice it to say that if a plate is exposed to the emanation for a short time, as the kathode in an electric field, it becomes coated with a strongly-active film of radium A. If the plate is removed from the emanation and left for some minutes, most of the radium A will have turned into radium B in position and after about a quarter of an hour practically no atoms of radium A will be left. It is to be noticed that the radium B formed remains on the plate. The thing is different when the experiment is carried out *in vacuo*, for according to the laws of probability half of the number of α particles ejected will be shot out from the radium A atoms away from the plate and half towards it. Thus in half the disintegrations of the radium A when an α particle is shot into the plate, the residual atoms of radium B possess momentum in directions away from the plate and will be detached unless there is some force preventing them from leaving. When the experiment is performed under ordinary conditions at atmospheric pressure, the atoms radium B are prevented from travelling more than of a fraction of a millimeter before colliding with molecules of air by which they are stopped; they then mostly diffuse back to the plate from which they came. On the other hand, *in vacuo* there is nothing to stop the motion of the atoms of radium B, and they continue on their course until they

FIGURE 2.

encounter some obstacle such as a second plate which may be placed at any convenient distance to catch them. The plate receiving the recoil may subsequently be removed and actually found to be coated with a deposit of radium B by testing in the usual manner with an electroscope.

The same thing may be accomplished in a somewhat different way, as was first shown by Hahn, by working at atmospheric pressure with an electric field as shown in the accompanying diagram (Figure 1).

The positively charged plate A, coated with radium A, is placed below the plate B which is negatively charged and insulated from the plate A. After a suitable exposure the plate B is removed and found to be coated with radium B.

Whichever mode of experimenting is adopted, it will be seen that the method of recoil affords a convenient means of separating a radio-active product from the parent substance from which it is formed, and this is perhaps the most important practical use to which these phenomena have been put. Indeed the method has already rendered great service in this direction, and its application has resulted in the discovery of new radio-active products.

To take two examples of particular interest which were first investigated by Hahn. It is well known that thorium possesses radio-active properties similar to those of radium, and gives rise to a number of disintegration products. In particular, at one stage of the transformations a gaseous emanation is formed, which was known to produce successively three radio-active substances—thorium A, thorium B, and thorium C. It was, however, unknown what became of the last of these products after disintegration. By using the method of recoil, it was shown that a previously undiscovered product was formed which was called thorium D. A similar case is that of radium C, which produces a series of slowly-decaying radio-active products. By exposing a plate to the recoil of radium C, a new substance has been isolated, which has been called radium C_2 to distinguish it from radium C, from which it is produced. The nature of the recoil has quite recently been studied by Fajans, and it would seem that, from the results so far obtained, an entirely new type of radio-active process is involved; but it is, perhaps, somewhat early to speak with absolute certainty on the matter as yet.

To turn again to the question of the dynamics of the atom, which we have seen can be studied in the case of radio-active recoil, and which has been subjected to experimental test by Russ, Evans, and the author. It has been mentioned that when the radio-active atom breaks up with the expulsion of an α particle, the residual atom recoils in such a way that its momentum is the same as that of the α particle. Now a charged particle in motion has been shown to act in many ways as an electric current, and will therefore be acted on by a magnetic field, just as is the case with a wire carrying an electric current. Moreover, if the particle is caused to move through a strong electric field applied at right angles to the direction in which it is travelling, it will be deflected from its course. This has been shown to be the case with α particles, and the same should be the case with a "recoil-stream" if this should prove to be charged.

Now the magnetic deflection depends upon the momentum of the particles, and therefore the deflection of the α particle and recoiling atom in a magnetic field of given strength should be the same if they carry the same charges. On the other hand, the electric deflection of the recoiling atoms should be greater than for the α rays, since this deflection can be shown to depend on the *energy* of the particles. These matters have been put to the test of experiment in the case of the recoil of radium B from radium A, and the magnetic and electric deflections observed show that the recoil-stream carries with it an electric charge. It is, however, remarkable that the deflections are such as to indicate that the charge on the α rays and recoil-stream is of the same sign—namely, positive. This fact gives rise to some interesting considerations as to what happens with the negative charge when the atom of radium A breaks up, but the point has not yet been definitely settled.

The magnetic deflection of the recoil-stream can be observed in different ways, of which perhaps the most interesting is to allow a narrow stream of radium B particles to pass *in vacuo* through a magnetic field and fall upon a brass surface. After some minutes the field is reversed and the brass subsequently removed and placed in contact with a photographic plate. The radio-active matter on the brass, photographs itself, giving two bands as shown in Figure 2, the distance between the bands representing twice the deflection suffered by the stream in passing through the field. An examination of the photograph shows that the deflection is only half that experienced by the α particles under similar conditions. From the law of momentum it may be inferred that the charge carried by the recoiling atom is half that on an α particle, or the atomic charge of electricity, since the α particle is known to be associated with twice that charge. The electric deflection of the recoil-stream has been measured in a somewhat similar manner, though not yet with the same accuracy. But though the precise manner of obtaining this information cannot be entered into, the results suffice to make certain important deductions regarding the mass of the atom of radium B—or, in other words, of its atomic weight. The result of the calculation is to show that the atomic weight of radium B is in the neighbourhood of two hundred, a result which had already been predicted from radio-active theory as follows:—The atomic weight of radium has been measured by several investigators, and found to be two hundred and twenty-six. Now radium gives rise to the emanation with the loss of one atom of helium, whose atomic weight is four. Thus the emanation should have an atomic weight of

two hundred and twenty-two, and since this in turn produces radium A and radium B successively, with the loss of an α particle in each case, the atomic weight of radium B should be two hundred and fourteen. The method of recoil thus gives an important confirmation of this theoretical deduction.

An account has been given of some new branches in radio-activity which have already been opened to investigation by the method of recoil. It seems not unlikely that many hitherto unsolved problems may receive explanation when attacked by this recently-discovered method.

ON DRAWING ELLIPSES.

By W. B. GIBBS, F.R.A.S.

IN the number of the *Journal of the British Astronomical Association*, for May, 1910, Mr. Hardcastle has given an interesting account of a method of forming the boundaries of an elliptic area by folding down segments of a paper circle according to the following rules:—

The paper circle is to be about six inches in diameter, the centre S is to be marked and also some other point H, which it is convenient to choose about two inches from the centre. On the circumference a number of points are to be marked. I myself find about thirty are desirable. K (Figure 1), will serve as an example of one of these points. The paper is then to be folded so as to bring K to H, and the crease is to be marked clearly. Then the paper is to be opened and the next point on the circumference is to be brought to H, and this new crease to be pressed clearly, and so on for the whole number of points. Then it will be found that a neat smooth area is left forming an ellipse about S and H, each crease being a tangent to the curve.

Now I find that this elliptical area can be made much more distinct, if, when the segments are folded down, they be shaded on the outer side with a lead pencil and then this shading well rubbed with the finger. Figure 2 shows an example of a shaded segment. When all the segments have been so treated and the paper is turned up, there will be seen on the lower side a clear elliptic area as shown in Figure 3, the tangent crease lines being also very plain.

Mr. Hardcastle's paper is well worth reading in its entirety. He gives a geometrical proof that the area is bounded by an elliptic curve, and also shows that it is not only interesting geometrically but that it can be used for dynamical purposes.

It is easily seen that ellipses of any degree of eccentricity can be drawn in this way, for from the properties of the ellipse $AS = A^1H = A^1K$ therefore AA is always equal to SK, or the major axis of the ellipse is equal to the radius we have chosen for our paper circle, while the minor axis continually decreases as H approaches K, vanishing absolutely when H coincides with K, the ellipse then becoming a straight line; but if H approaches S then the minor axis gradually increases, and ultimately, when H coincides with S, becomes equal to the major axis, and the ellipse becomes a circle whose radius is equal to one-half the radius of the original paper circle.

If the radius of the original be 3 inches

Then AS = $\frac{1}{2}$-inch

and the minor axis = $1\frac{4}{5}$-inches

from formulae given in all treatises on conic sections.

In order to draw elliptic orbits by this method, I subjoin the accompanying table giving the eccentricities of the orbits which correspond to those values of SH which lie between two and three inches, proceeding by thirty-seconds of inches. This will be available for all comets which move in closed orbits. Taking, for example, Encke's comet, the eccentricity of which is ·8476, we see at once we must take SH between $2\frac{17}{32}$ inches and $2\frac{9}{16}$ inches, because ·8476 lies between ·84375 and ·8541, the nearest numbers given in the table.

In Figure 4 I give a representation of this orbit.

Distance between H and S in fractions of an inch	Distance between H and S in corresponding decimals.	Eccentricity or e.
2	2	·666
$2\frac{1}{32}$	2·03125	·67708
$2\frac{1}{16}$	2·0625	·6875
$2\frac{3}{32}$	2·09375	·69791
$2\frac{1}{8}$	2·125	·708
$2\frac{5}{32}$	2·15625	·71875
$2\frac{3}{16}$	2·1875	·7291
$2\frac{7}{32}$	2·21875	·73958
$2\frac{1}{4}$	2·25	·75
$2\frac{9}{32}$	2·28125	·76041
$2\frac{5}{16}$	2·3125	·7708
$2\frac{11}{32}$	2·34375	·78125
$2\frac{3}{8}$	2·375	·791
$2\frac{13}{32}$	2·40625	·80208
$2\frac{7}{16}$	2·4375	·8125
$2\frac{15}{32}$	2·46875	·8229
$2\frac{1}{2}$	2·5	·833
$2\frac{17}{32}$	2·53125	·84375
$2\frac{9}{16}$	2·5625	·8541
$2\frac{19}{32}$	2·59375	·8646
$2\frac{5}{8}$	2·625	·875
$2\frac{21}{32}$	2·65625	·8854
$2\frac{11}{16}$	2·6875	·8958
$2\frac{23}{32}$	2·71875	·90625
$2\frac{3}{4}$	2·75	·9166
$2\frac{25}{32}$	2·78125	·9271
$2\frac{13}{16}$	2·8125	·9375
$2\frac{27}{32}$	2·84375	·9479
$2\frac{7}{8}$	2·875	·9583
$2\frac{29}{32}$	2·90625	·96875
$2\frac{15}{16}$	2·9375	·9791
$2\frac{31}{32}$	2·96875	·9896
3	3	1·

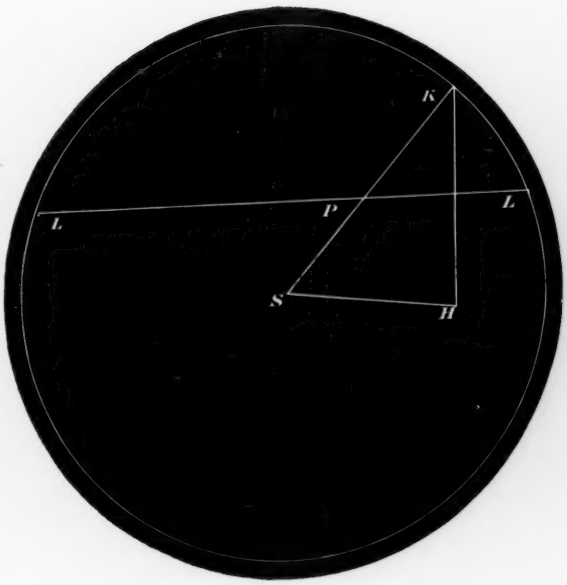

FIGURE 1.

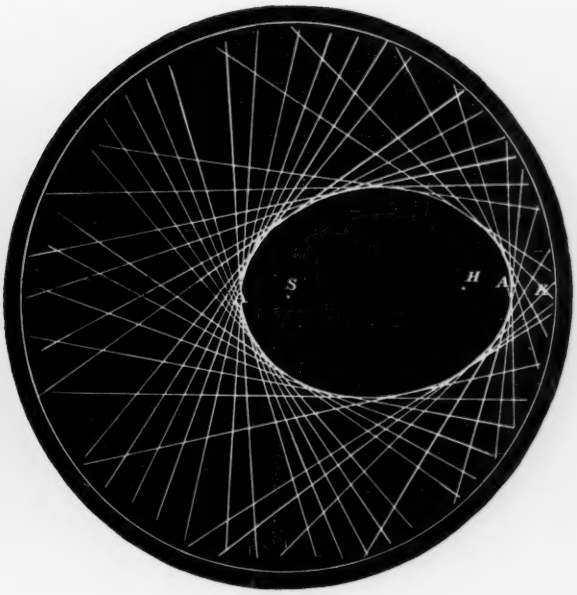

FIGURE 3.

FIGURE 2.

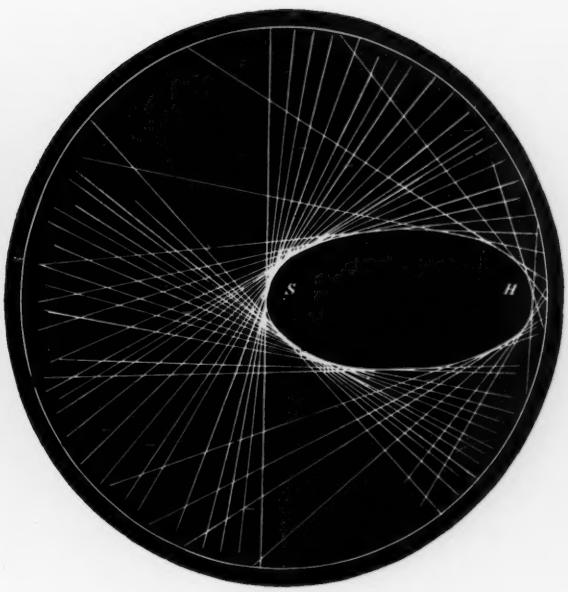

FIGURE 4.

ON LOADED TELEPHONE CABLES.

By Dr. J. A. FLEMING, F.R.S.

Professor of Electrical Engineering in University College, London.

When the telephone was first invented and began to be used, more than thirty years ago, anticipations were indulged that it would be possible to transmit the songs of an operatic prima donna or the speeches of a public orator by submarine cable between Europe and America. But a very little experience showed that severe limitations existed to the transmission of telephonic speech through a cable. The reason for this is the electrostatic capacity of the cable. A copper wire surrounded by gutta-percha or indiarubber, and buried in the sea or soil, forms a virtual Leyden jar of large capacity. The electrical capacity of an ordinary Leyden jar, such as is used in wireless telegraphy, may be about one-five-hundredth of a microfarad. The capacity of one mile of submarine cable may be one-third of a microfarad, or nearly one hundred and seventy times as much. Hence even twenty or thirty miles of submarine cable has a very considerable capacity; and the capacity of an Atlantic cable is about eight hundred microfarads, or about the same as the capacity of the whole earth considered as a sphere free in space. The effect of this capacity is that if we attempt to send an electric current through the cable it has (so to speak) to be filled up with electricity before any current begins to flow out at the distant end. Moreover, if we make sudden changes in the strength of the current at the sending end, these changes are not reproduced instantly at the other end, or in the same degree. The mathematical theory shows that the speed with which these current changes travel along the cable depends upon their frequency. Also, the degree to which the amplitude of these changes decreases, or *attenuates*, depends upon their frequency, and upon the constants or structure of the cable. Current changes of high frequency attenuate more rapidly and travel faster than those of low frequency.

Now when an articulate word is spoken to the diaphragm of a telephone transmitter, the rapid changes of air pressure which constitute sound, compress the diaphragm and produce corresponding changes of resistance in the carbon granules of the microphone. These again cause variations of like nature in the electric current entering the cable. These current variations are a more or less complete copy of the air pressure changes. If the cable could transmit these current changes unaltered to the telephone receiver at the other end, speech would be perfectly reproduced. The wave-form, or mode of current variation, which corresponds to articulate speech, is very complicated, but it may be resolved into the sum of a number of vibrations of different frequency and amplitude. The effect of the electrical capacity of the cable, as already mentioned, is to cause an attenuation, or weakening, in the amplitude of the current vibrations as they are transmitted along the cable, and this attenuation affects the higher or shrill notes more than the lower or deep notes. Also the higher notes travel faster than the lower ones. It will easily be seen that the result of this inequality is that the wave-form of the current is *distorted* by transmission. The different constituent notes or harmonic vibrations arrive at the far end of the cable unequally degraded, or attenuated, and shifted in phase relatively with each other, the high vibrations having outrun the lower ones.

If this distortion has not proceeded beyond a certain limit, the ear of the listener is able to guess, from the sound heard, the meaning of the word, just as in the case of bad or ordinary handwriting we are able to guess from the general shape of the written word what it means although the individual letters are badly formed or distorted. If, however, the distortion has proceeded beyond a certain point, then the ear is unable to attach a meaning to the sound heard. Apart, therefore, from any imperfection in the actual telephonic instruments, or in the speech or hearing of the two communicants, we have a limit to the telephonic transmission of speech, imposed by the distortional qualities of the cable itself. Accordingly, it was soon found that the limiting distance of speech through an ordinary submarine telegraph cable might be taken as twenty miles or so, depending on the size of the core. In the case of land, or overhead, lines, this limiting distance is very much larger. The capacity of an overhead line per mile is not a one-hundredth or one two-hundredth of that of a submarine cable, and therefore telephonic speech is possible through several hundred miles of ordinary overhead wire.

The question of the improvement of telephony by underground and underwater cables soon began to be discussed, and foremost amongst those whose writings assisted in laying the true scientific foundation was Mr. Oliver Heaviside. He showed that the true antidote to the capacity effects of the cable was to add to it inductance. This term may be defined, for the ordinary reader, as follows:—A coil of wire, especially a coil of many turns, possesses a property in virtue of which a current started in the wire tends to run on, and also the starting of a current takes time. Inductance, electrically speaking, corresponds to inertia in the case of ordinary matter. Generally speaking, we may say that the presence of inductance hinders rapid changes of currents in a line, just as inertia in machinery hinders very rapid changes of speed in moving parts. For this reason non-mathematical electricians of the old school had arrived at the idea that inductance in a telephone line should be

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reduced as much as possible. On the contrary, Mr. Heaviside showed that what most telephone lines required was not less, but more, inductance, to make them less distortional. In short, inductance is capable of neutralizing capacity in cables. The reason for this is that capacity in cables acts as if it were a sort of vacuum, into which electricity tries to rush just as air rushes into a gaseous vacuum. On the other hand, inductance opposes the movement of electricity and hence inductance in series with capacity can be made,

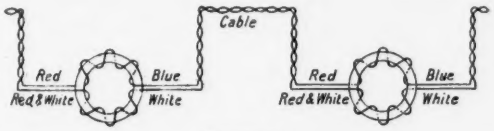

FIGURE 1.

Mode of inserting the loading coils in the two sides of a telephone cable.

by suitable adjustments, to neutralize each other. The suggestion was therefore made as far back as 1887 that to effect an improvement in the qualities of the line it was necessary to add inductance to it. All problems in engineering are, however, ultimately questions of cost and detail, and until it had been practically shown that this addition of inductance was both economical and advantageous, telephonic engineers were hardly justified in embarking on expensive constructions. In 1899 and 1900, however, Professor Pupin, in the United States, published the results of some remarkable investigations on this subject. He showed that if coils of wire (called loading coils, see Figure 1) having high inductance were inserted in the run of a telephone cable at equal distances, and so close that nine or ten of the coils were covered by or included in one wave of the current, the result was as if the inductance were smoothly distributed over the cable and also that provided the inductance were large enough, a considerable improvement in the speech-transmitting qualities resulted. The phrase, wave of current, needs a little explanation. The characteristic of a wave motion of any kind, whether in air or water, is that some change is periodically made in the medium, which is repeated successively at contiguous points. If we have a long cable, at one end of which some kind of periodic or alternating electromotive force is applied, then the changes in potential are not reproduced instantly at all points in this cable, but are propagated from point to point in it with a certain velocity. The more rapid these changes the faster they travel, up to a limiting value which is equal to that of light. At certain points in the cable, separated by distances called one wave-length, changes of potential of similar type take place at the same time; that is to say, the potential becomes zero or a maximum at the same instant. It is found that the mean value of the frequency involved in ordinary speech is nearly eight hundred. That is, the mean pitch of the aërial vibrations has this value.

Corresponding to this frequency in a telephonic cable the wave-length may be ten to twenty miles or so. Now a telephonic or telegraphic cable has four specific qualities. Its conductor has a certain resistance per mile reckoned in ohms, and also a certain inductance measured in units called a henry. Also it has a certain capacity per mile, and a certain leakage per mile.

Mr. Heaviside first showed that to make a cable distortionless in the sense that waves of all frequencies would travel along it at the same rate, it is necessary that the product of the resistance and of the capacity per mile shall be equal to the product of the inductance and leakage per mile.

In all ordinary cables the capacity is too great to fulfil this condition, and hence we have to increase the inductance to approximate to the distortionless condition.

Pupin showed that we can add this inductance in lumps, so to speak, provided we insert these lumps of inductance at such intervals that there are nine or ten coils per wave-length at a frequency of eight hundred. A telephone cable so constructed, with inductance coils inserted in it every mile or so, is called a *loaded cable*, and loaded cables have of late years played an important part in improving telephonic communication. After the publication of Pupin's researches attempts were made to put them to practical test in long overhead telephone lines, both in the United States and in Germany. The results were very encouraging, and the attention of telephonic engineers was closely directed to the

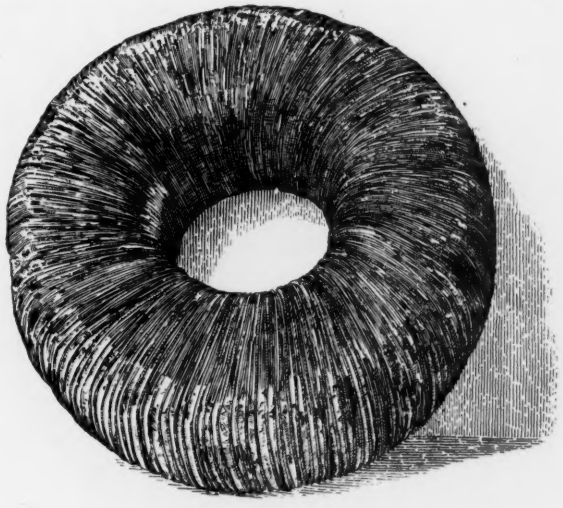

FIGURE 2.

A loading coil for loaded telephone cables as used by the National Telephone Company.

subject. It is a comparatively easy matter to insert such inductance coils in an overhead line, because they can be attached to the telegraph posts, a coil being inserted in the line circuit every mile or so.

The coils used consist of iron rings built up of fine iron wire which are wound over with many

turns of silk-covered copper wire like a transformer (see Figure 2). These loading coils are enclosed in iron cases and fixed on the posts. It is easy to construct such a coil to have an inductance of about 0·1 henry, and a resistance of only ten to fifteen ohms.

Loading coils can also be easily inserted in the run of underground telephone cables, and such loaded circuits have been much employed of late years by the National Telephone Company (see Figure 3). A more interesting and recent application is in the case of submarine telephone cables. So inferior is even a length of twenty miles or so of submarine cable to an equal or even much greater length of aërial line in the transmission of telephonic speech, that the great obstacle in conducting telephonic communication with Ireland or the Continent has always been the interposition of the twenty to eighty miles of submarine cable necessary to cross the English or Irish Channel. The problem of loading a submarine cable was, however, one of peculiar difficulty. In any case the laying of an unloaded submarine cable rather reluctant to embark on the enterprise of laying a submarine cable having heavy protuberances in it every mile or so. Hence as a first step attempts were made at continuous loading. The inductance of a cable can be increased by winding over it many layers of fine iron wire separated, however, from the copper by an insulation. The effect of this is to increase the magnetic field surrounding the conductor when a current flows through it. Such a continuously loaded cable will be thicker and heavier than an ordinary unloaded cable, but the risks in laying it are not thereby seriously increased. Several continuously-loaded telephone cables were laid in Denmark. There are however, difficulties in the way of foretelling the actual performance of such a class of cable, which do not exist in the case of cables loaded in the Pupin manner. The first cable of this last type laid under water was that put down a few years ago in Lake Constance. The length of this cable is nine miles and it consists of a paper-insulated lead-covered cable, having loading coils inserted in it at intervals. The

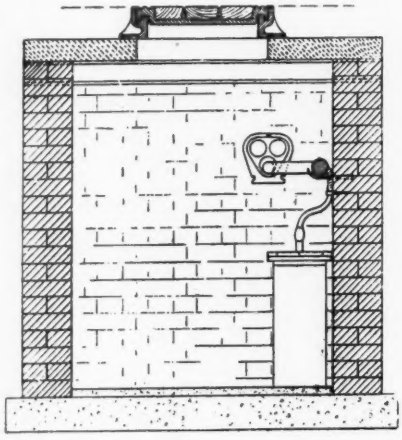

FIGURE 3.

A brick pit for containing the loading coils inserted in telephonic cables.

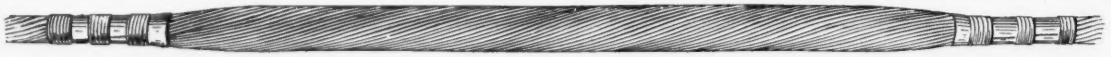

FIGURE 4.—Section of cable containing loading coils, complete with sheathing wires.

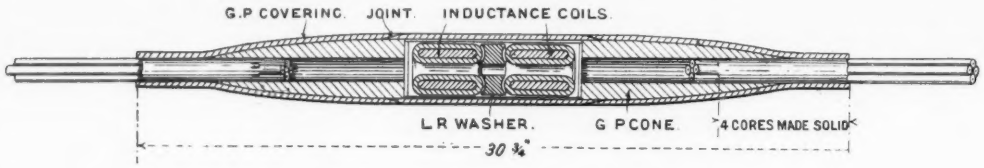

FIGURE 5.—Arrangement of coils in cable.

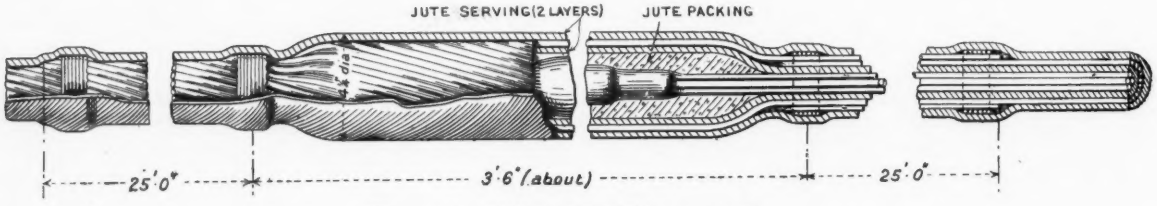

FIGURE 6.—Method of sheathing over coils.

involves engineering difficulties of a considerable kind. Even when the advantages of inserting the loading coils had been well ascertained, cable engineers were performance of this cable was such as to encourage further developments, and a year or so back, when the authorities of the British Postal Telegraph service

began to consider the laying of a new telephone cable across the English Channel, the question of a loaded cable was seriously considered. After many experiments and measurements, a type of Pupin-loaded cable was evolved which was made and laid for the Post Office by Messrs. Siemens Brothers, in 1910. This Anglo-French loaded telephone cable was described to the Institution of Electrical Engineers recently in a paper by Major O'Meara, C.M.G., the Engineer-in-Chief of the British Postal Telegraph Department.

FIGURE 7.

Passing over the sheave a loading coil in the Anglo-French telephone (1910) cable laid across the English Channel.

The cable contains four-stranded copper conductors insulated with gutta percha in the usual way, and every nautical mile, coils are inserted which consist of silk-covered wire wound over an iron core so as to form an inductance coil which is inserted in the run of the cable (see Figure 5). The gutta percha insulation and the steel wire armouring are, of course, continued over the coil, and the result is to produce an enlargement or protuberance on the cable every mile.

The cable was laid with great skill by the manufacturers at the bottom of the English Channel between Abbots Cliff, near Dover, and Cape Grisnez, in France.

The cable was laid by the cable ship "Faraday" by the experienced operators of Messrs. Siemens Brothers, and under the inspection of officials representing the British and French Telegraph Services, between May 15th and May 18th, 1910. Some special precautions had to be taken in handling the thickened-up portions of the cable containing the loading coils (see Figure 7). The operations were, however, successfully carried out, and London and Paris are now connected by a new telephone cable of superior type containing two complete circuits. The attenuation constant of the new cable or ratio in which the current is enfeebled in passing along the cable was found to be close to the predicted value, and the speaking qualities of the cable also fully realised expectations. By the employment of extra thick conductors in the land lines at each end, and when the added distances do not exceed seventeen hundred miles, Major O'Meara states in his paper that well maintained conversations by telephone could be conducted between London and Astrakhan on the Caspian Sea. This important achievement has been watched with great interest by practical telephone engineers on both sides of the Atlantic. The great improvement in the distances over which it is possible to speak telephonically through cables when loaded in the Pupin manner is a great testimony to the value of correct scientific theory in guiding practice. The old rule-of-thumb methods are abolished, telephonic engineers are everywhere engaged in studying the improved methods of

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predicting the effect upon the speaking qualities which of certain constructions in telephonic cables have been based upon the researches of Heaviside and Pupin, and chiefly reduced to simplicity by the work of Dr. Kennelly, of Harvard University, U.S.A.

The writer of this article delivered last year to a large class of practical telephone engineers a course of Post-Graduate Lectures on this subject on behalf of the University of London, and these Lectures have just been published by Messrs. Constable & Co., in a book entitled "The Propagation of Electric Currents in Telephone and Telegraph Cables" in which a full discussion of the scientific questions involved in loaded telephone cables is given.

CORRESPONDENCE.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I much appreciate the article of Mr. Annison on the Fourth Dimension: I regard it as peculiarly fortunate that I happened to refer to the subject in my letter on The Eternal Return. Just recently I devoted a fair amount of thought to the subject of meta-space, approaching it from the geometrical side. The principal difficulty is, I think, that of determining what analogies are justifiable. For instance, it may be argued: A line can revolve about a point in two-dimensional space (2 D. space), and a plane can revolve about a line in 3 D. space; therefore, a volume can revolve about a plane in 4 D. space. This seems straightforward, but actually we need to examine more closely the meaning of the word "revolve." Suppose we say that "to revolve round" means "to move continuously at constant normal distance from." Then we must be careful when talking about a body revolving about a line. A body moving in a circle should not be said to move at constant normal distance from a straight line, but from a curved line—any other coplanar, concentric circle, in fact.

Thus, instead of expecting a Euclidean plane to be a fulcrum and axis in 4 D. space, we should regard a sphere and "meta-cylinder" as such.

Now, of course, it is possible to obtain rotation "about a sphere" in 3 D. space, except that, practically, it is difficult to devise suitable mechanism. However, my own incomplete geometrical investigations have shown that, even in 3 D. space, very curious projected motions arise from a point revolving "spherically." For instance, suppose we have a ball revolving about an axis (using common parlance), and that this axis is revolving about a line bisecting it at right angles, the two component angular velocities being the same; then differently situated points move in differently shaped loci "in space." Each "pole" for instance, has the following locus.

Front elevation.—A figure of eight.

Plan.—Two coincident circles, of diameter equal to *half* that of sphere.

Side elevation.—Two coincident half-sine-curves.

This may seem irrelevant to the subject of the fourth dimension, but actually it is not. When one realises the vast number of 3 D. motions which, either by projection or section, are similar in 2 D. space, one realises the magnitude of the task of trying to identify 4 D. figures and motions by their 3 D. manifestations.

I hope this letter is not unduly long, but I should just like to say this: As I hinted in the last sentence of my former letter, we must not lose sight of psychological considerations in these matters. However, I think that something profitable might arise from cogitation along the following lines. Instead of utilising the analogy of 2 D. beings who "sense" 3 D. objects by their sections in a 2 D. world, we should rather deal with 3 D. beings whose "introspectible consciousness" (forgive the term!) is limited to two dimensions whilst they actually live and move in three. The analogy must not be pushed too far, but think of *men*, who, whilst living and acting (to a limited extent) in a 3 D. world, sense objects (including one another) by means of shadows cast on a wall; also remember how easy it is for visual space and "loco-motor" space to be dissociated, as, for instance, when shaving or arranging one's hair, one thinks of the visual operation as occurring "in the mirror." Unfortunately, there is a lack of written matter on the fourth dimension; although I may be allowed to mention Mr. C. H. Hinton's "Fourth Dimension" (Sonnenschein).

J. JOHN ELLIOTT.

THE SELENIUM PHOTOMETER.

To the Editors of "KNOWLEDGE."

SIRS,—I desire to make a few remarks with reference to your note on the application of the Selenium Photometer to the measurement of starlight.

First, let me protest against the use of the term *Selenium "cell"* to the selenium *resistances*, which are commonly employed in photo-electricity. In 1895 I used at the Daramona Observatory, Westmeath, a selenium *cell*, properly so called, for comparing the lights of stars (see the *Proceedings of the Royal Society* Volumes LVIII and LIX). This cell contained a liquid; and in the cell the light of a star generated an electromotive force, the cell being thus quite distinct from the ordinary selenium *resistance*, in which increased conductivity is produced by light. In the *Proceedings of the Royal Society*, Volume LXXXI, 1908, I described a form of selenium resistance, called a *selenium bridge*, which is suitable for star measurement; and I also pointed out a fallacy involved in the usual employment of selenium for comparing two lights. I am afraid that no notice has been taken of this fallacy. In the last-named paper are given the results of exposing a selenium bridge to the infra-red, red, yellow, blue, and ultra-blue parts of the spectrum of one and the same source of light. The effects of red and blue are enormously different, the red producing much greater effect. Hence it will be seen that if we compare the light of Sirius or Vega with that of Aldebaran or Betelgeuse, we are not doing justice to the former stars if we merely allow the total light of the star to fall on the selenium, and measure it by the electrical effect produced. We should proceed quite differently. We should split up the various lights into their spectra, and compare two stars, colour by colour.

This, of course, requires large telescopes, of which this country possesses none available; but in America the thing could be done properly.

I send you a copy of my 1908 paper, from which you will see how necessary it is to use spectra when comparing two stars, and how suitable the *selenium bridge* is to the purpose. The bridge is so narrow—as narrow as the thinnest flake of mica—that the light in any line of a spectrum can be measured.

Another thing of vital importance is to keep aqueous vapour from the surface of the bridge, or other form of selenium resistance; otherwise we get spurious conductivity. I rather think that this fact has not been attended to in America; but I have actually constructed an *electric hygrometer* depending on the presence of vapour on the bridge.

I have been hoping to use the selenium bridge here in the Radcliffe Observatory, for spectrum comparison of stars; but the telescope available is only one of small aperture, and other work has prevented observations.

GEORGE M. MINCHIN.

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A NOTABLE RECORD.

CAPTURE OF A NEW SPECIES OF *MYMAR*.

By FRED ENOCK, F.E.S., F.L.S., F.R.M.S.

LAST July (1910), it was my pleasure to record in the pages of "KNOWLEDGE," the interesting fact that I bred that wonderful insect, *Mymar pulchellus*, the Battledore Wing Fly, on June 14th, when a male and female emerged from their host egg. During the past winter, I made collections of various stems of plants, in and upon which I found numbers of eggs, cunningly hidden away, in the pleated leaves of grasses, or embedded in the stems in such a manner that the utmost care is needed to detect them and preserve them from drying up or becoming mouldy. Great ingenuity is displayed by the parent in distributing them either singly or in groups of three or four, so that the minute operculum shall be just flush with the outer covering. Sometimes a single hole is made about a sixty-fourth of an inch in diameter, and through this minute opening, seven or eight eggs are laid in such a manner that the head end (a mere point), starts from this hole. It is such eggs that the *Mymaridae* search for with unwearying care, running up and down the stems, keeping up an incessant drumming with their clubbed antennae—the under-side near the tip being covered with most delicate sensory hairs—until, by their marvellous sense of touch or hearing, an egg of the right species of host—(not *any* other), is located. The tip of the ovipositor is then brought into position until it is at right angles with the stem, and the boring through the egg-shell commences, the tiny mechanic bringing its muscular power to bear upon the microscopic "broach" which gradually goes deeper and deeper and then with a bump goes right through, sometimes up to the base. The germ is transmitted, sealing the doom of the host's egg—the fluids of which go to the nourishment of the ovivorous larva. I have repeatedly observed the oviposition of many of the *Mymaridae*.

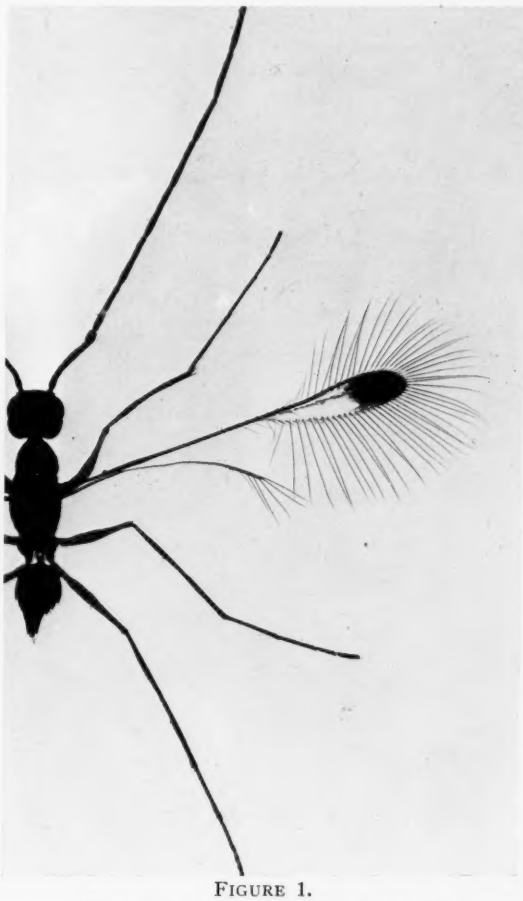


FIGURE 1.
Mymar regalis, new species (enlarged).

The intense heat of June has brought out *Mymar pulchellus* in confinement four days earlier than in 1910. Of some species we have but single specimens—and have yet to obtain more data before we can state the time of their appearance. One of these is Walker's genus *Limacis*—of which but five specimens are known. Mr. Waterhouse has taken a male and female; my nephew, Mr. John Enock a female, and I have one, a male. *Limacis* is, we find, one of the earliest to appear—in May. On June 3rd, I had a long day's sweeping for it at Burnham Beeches, but without success. I only captured a dozen very common species, and I confess to feeling a little disheartened; for five hours sweeping and examining the contents of one's net with a magnifier is very trying and fatiguing work. I had almost decided to pack up my kit, when I noticed a likely stretch of grass, which I swept. On examining the sweepings of grass seeds, and bits of sharp tipped rushes I was very pleased to see the familiar form of *Mymar* running and skipping about in its own peculiar manner—running along with its battledore wings arched over its back, then after a sudden pause—and a jump—somewhere, the search begins again, until at last a phial is placed over it, and safely corked. This was my thirteenth phial, and I wended my way to the motor-'bus

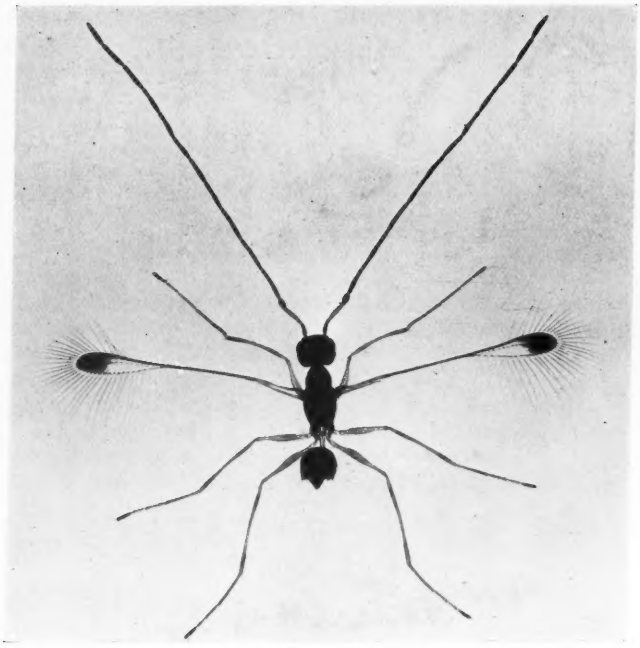


FIGURE 2.
Mymar pulchellus (male) enlarged 30 diameters.

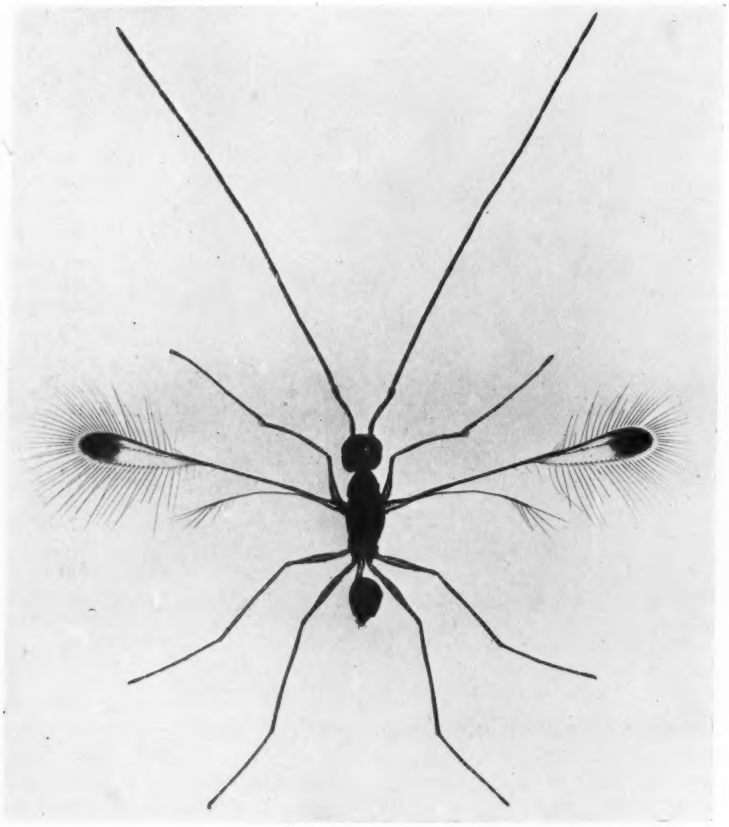


FIGURE 3.
Mymar regalis (male) new species, enlarged 30 diameters.

for Slough, little dreaming that in that phial No 13, was the most wonderful capture made for many years. On reaching home, I killed my twelve captures, then *Mymar*, and was proceeding to brush and clean it—its battledore wings were in a perfect tangle requiring care to undo—when I was much troubled by a minute piece of fluff or dust, which I could not remove, so placed the *Mymar* under the microscope, when I was astonished beyond description, for I looked for an ordinary *Mymar pulchellus* with its abnormally short under-wings, instead of which, the fluff I had tried to remove was an *elongated* posterior wing, with cilia of six hairs, and I realized that I had captured a brand new species of *Mymar*! As soon as I had mounted it in balsam I telegraphed to Mr. C. O. Waterhouse :—" Captured new species of *Mymar*, with battledore shaped under-wings." This brought us together, and we gloated over the distinguished visitor. I suggested that we should christen it *Mymar regalis*, in honour of His Most Gracious Majesty, King George V.

On Thursday, June 8th, Mr. C. O. Waterhouse and I had a day at Burnham, and after five hours sweeping in a broiling sun, I was fortunate in obtaining another male, so confirming the genuineness of the species, which not only differs from *pulchellus* in its posterior wings, but the cilia around the anterior pair are composed of some sixty long hairs against thirty-five in *pulchellus*. In other respects, the colour and markings are similar. Another long day in search of the unknown female was not by any means a successful one; in fact, this *Mymar* is but the one twenty-fifth of an inch in length, and searching for such a creature on a wide expanse of wood and common requires a large amount of patient labour.

SOLAR DISTURBANCES DURING MAY, 1911.

By FRANK C. DENNETT.

ON ten days during May, namely the 10th to 18th, inclusive, and the 24th, only faculic disturbances were visible on the disc, dark spots being seen on the remaining twenty-one. The longitude of the central meridian at noon on May 1st, was 152° 46′.

Nos. 17, 17*a* and 17*b*, continued upon the disc until May 3rd, 5th and 2nd respectively, and so appear again upon the accompanying chart.

No. 19.—A pore amid a faculic disturbance within the eastern limb on the 2nd, and remaining until the 5th, the facula being still visible as it neared the western limb on the 14th.

No. 20.—Broke out as a pair of pores 22,000 miles apart, on the 4th. Next day the following one had increased to a spotlet, and on the 6th it had developed to an elongated ellipse, with a major axis 48,000 miles in length. It attained its maximum length of 74,000 miles on the 7th. The dwindling group reached the western limb on the 9th. Some of the members on the 6th appeared as slits in the photosphere.

No. 21.—On May 4th, a pore very similar to No. 19, appeared in a faculic disturbance a little north-east of that disturbance. Next day two pores were seen with others ranged behind them like the border of an ellipse, with a length of 48,000 miles. Much change took place in the appearance of the group, which was last seen as six pores outlining an oval area 26,000 miles in greatest diameter, on the 9th.

No. 22.—A pair of pores 19,000 miles apart, with tiny dots between them, only seen upon the 9th.

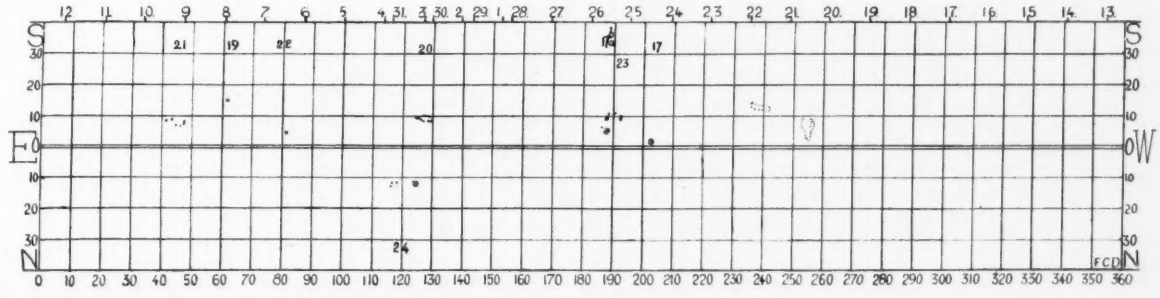
No. 23.—A spot seen on the 19th close within the eastern limb. On the 21st it appeared to have a bridge across the umbra, and also to be situated near the head of a considerable faculic disturbance. Only two close umbrae were visible amid faculae on the 22nd, but when last seen on the 23rd, there were three pores forming a triangle, the longest side being 33,000 miles. The area still showed faculic disturbance as it approached the western limb on May 31st.

No. 24.—Bright faculic ridges were visible on the morning of the 25th near the eastern limb, a little north, containing a tiny pore. Other pores showed later and a spot over 7,500 miles in diameter developed during the afternoon. The latter expanded until 14,000 miles across. The umbra was penetrated by a bright projection from the south, from the 28th until the 30th. The penumbra brightened at its inner border from May 30th until last seen on June 5th. It was followed from the 24th until the 31st, by a group of pores extending back 63,000 miles, and some were seen on the 1st and 3rd, close up to the large spot. During its visibility it had a forward motion on the Sun's surface amounting to fully 5° or 37,000 miles.

Bright faculic disturbances were visible within the eastern limb on the 16th, in the positions shown dotted on the chart, about longitudes 240° and 255°.

Our chart is constructed from the combined measures, drawings, and descriptions of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, and F. C. Dennett, working respectively at Lisburn, Chorlton-cum-Hardy, Bath and Hackney.

DAY OF MAY, 1911.



THE FACE OF THE SKY FOR JULY.

By W. SHACKLETON, F.R.A.S., A.R.C.S.

THE SUN.—On the 1st the Sun rises at 3.48 and sets at 8.18; on the 31st he rises at 4.22 and sets at 7.50. On the 3rd at 6 a.m. the earth is at its greatest distance from the Sun, the solar parallax then reaching its minimum value of 8″·66.

Sun spots may occasionally be observed on the solar disc in spite of the declining solar activity; at the time of writing no spots were visible.

The positions of the Sun's axis, equator, and the heliographic longitude of the centre of the disc, are shown in the following table:—

Date.	Axis inclined from N. point.	Centre of Disc N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
June 30 ...	3° 25′W	2° 50′	78° 55′
July 5 ...	1° 8′W	3° 23′	12° 44′
,, 10 ...	1° 9′E	3° 53′	306° 33′
,, 15 ...	3° 24′E	4° 23′	240° 23′
,, 20 ...	5° 37′E	4° 51′	174° 13′
,, 25 ...	7° 46′E	5° 17′	108° 5′
,, 30 ...	9° 52′E	5° 41′	41° 56′
Aug. 4	11° 52′E	6° 2′	335° 49′

THE MOON:—

Date.	Phases.	H. M.
July 3 ...	☽ First Quarter	9 20 a.m.
,, 11 ...	○ Full Moon	0 53 p.m.
,, 19 ...	☾ Last Quarter	5 31 a.m.
,, 25 ...	● New Moon	8 12 p.m.
Aug. 1 ...	☽ First Quarter	11 29 p.m.
July 9 ...	Apogee	2 42 a.m.
,, 24 ...	Perigee	10 36 a.m.

OCCULTATIONS.—No occultations of naked eye stars are visible in this country during the present month or early August.

THE PLANETS.

MERCURY:—

Date.	Right Ascension.	Declination.
	h. m.	
July 1 ..	6 24	N 24° 21′
,, 11 ...	7 56	22° 37′
,, 21 ...	9 14	17° 36′
,, 31 ...	10 14	11° 19′
Aug 10 ...	10 59	N 5° 8′

Mercury is in superior conjunction with the Sun on the 4th. After the 20th the planet sets about an hour after the Sun in the W.N.W., thus for all practical purposes he is unobservable, being in too bright a portion of the sky after Sunset.

VENUS:—

Date.	Right Ascension.	Declination.
	h. m.	
July 1 ...	9 47	N 14° 52′
,, 11 ...	10 22	10° 46′
,, 21 ...	10 54	6° 30′
,, 31 ...	11 20	N 2° 18′
Aug. 10 ...	11 39	S 1° 32′

Venus continues to be a conspicuous object in the evening sky looking W. immediately after Sunset. The planet is increasing in brilliancy, and reaches her "greatest brilliancy" on August 10th, whilst on July 7th she is at greatest easterly elongation of 45° 29′ from the Sun. At the beginning of July the planet sets about 10.30 p.m., and at the end of the month, about 9 p.m.

The planet is so bright that most persons are able to see it long before it is dark, and this is the best time for observing with a telescope. The planet may readily be seen, even in broad daylight if slight optical aid, such as a pair of opera glasses, be employed and directed to the correct position in the sky. With the help of nothing but a pair of opera glasses and a celestial globe, I was able to find the planet in the early afternoon, and after finding it with the glasses it was fairly easy to see the planet with the naked eye, when shielded from direct sunlight. During July, the planet is on the meridian about 3 p.m.; 3.13 on the 1st and 2.48 on the 31st, and as the brightness is increasing, it should be fairly easy to discern in the afternoon. As seen in the telescope, the planet appears like a half moon at the beginning of July, but the phase rapidly changes, so that at the end of the month the form is crescent, 0·3 of the disc being illuminated, the apparent diameter increasing from 22″ to 32″ in the same period. The Moon appears near the planet on the evening of the 28th.

MARS:—

Date.	Right Ascension.	Declination.
	h. m.	
July 1 ...	1 18	N 6° 1′
,, 11 ...	1 44	8° 29′
,, 21 ...	2 9	10° 47′
,, 31 ...	2 34	12° 53′
Aug. 10 ...	2 58	N 14° 44′

Mars rises about ten minutes after midnight on the 1st and at 10.50 p.m. on the 31st. The planet is situated in Pisces and appears about half a degree S. of ο Piscium on the 10th; he is rather an inconspicuous object, but as the opposition of November approaches, he will become more interesting. The planet is increasing in brightness, the apparent diameter on July 1st being 8″·0 and on August 1st, 9″·3.

The latitude of the centre of the disc is about −19°; thus the southern polar cap is visible, and it is approaching summer in the southern hemisphere of the planet, the summer solstice occurring on August 1st.

JUPITER:—

Date.	Right Ascension.	Declination.
	h. m.	
July 1 ...	14 11	S 11° 58′
,, 11 ...	14 12	12° 3′
,, 21 ...	14 13	12° 13′
,, 31 ...	14 16	12° 29′
Aug. 10 ...	14 19	S 12° 50′

Jupiter appears as a brilliant star looking S.S.W. at sunset. The planet sets at 0.42 a.m. on the 1st, and at 10.40 p.m. on the 31st.

For small telescopes this is the easiest and most interesting planet to observe, on account of his brightness, numerous moons, the markings on the disc and polar flattening. A telescope magnifying about fifty times shows the planet of the same apparent diameter as the moon seen with the naked eye; with this magnification and an aperture of two inches, the belts may be seen, but the moons, when not too near the planet, may be seen in any good pair of field glasses.

The equatorial diameter of the planet on the 25th is 37″, whilst the polar diameter is 2″·4 smaller; this polar flattening is readily observed in telescopes powerful enough to see the belts. If sufficient magnification be used, the Great Red Spot on the belts may be seen, and the period of rotation deduced. This is very short, and accounts for the oblateness, being only $9^h\ 55^m$.

The following table gives the Satellite phenomena:—

Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.
July				July				July			
1	I.	Sh. I.	10 24	6	II.	Sh. I.	10 3	24	I.	Tr. I.	9 22
1	I.	Tr. E.	11 27	8	I.	Tr. I.	11 7	24	III.	Ec. R.	9 32
2	I.	Ec. R.	9 44	13	III.	Tr. E.	10 45	25	I.	Ec. R.	9 57
2	II.	Sh. I.	11 17	16	I.	Oc. D.	10 9	Aug.			
2	II.	Tr. E.	11 36	17	I.	Tr. E.	9 40	2	I.	Sh. E.	9 14
								9	I.	Sh. I.	8 57

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc, and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

The configurations of the Satellites as seen in an inverting telescope, and observing at 9.30 p.m., are as follows:—

Day.	West.	East.	Day.	West.	East.
1	43 ⊙ 2		17	42 ⊙ 3	
2	43 ⊙	●1	18	4 ○ 1 3	●2
3	421 ○ 3		19	41 ○ 23	
4	4 ○ 213		20	42 ○ 31	
5	41 ○ 23		21	4321 ○	
6	243 ○ 1		22	34 ○ 12	
7	321 ○ 4		23	314 ○ 2	
8	3 ○ 124		24	2 ○ 14	●3
9	3 ○ 24	●1	25	2 ○ 34	●1
10	21 ○ 34		26	1 ○ 234	
11	○ 134	●2	27	2 ○ 314	
12	1 ○ 234		28	$\frac{3}{4}$1 ○ 4	
13	2 ⊙ 14		29	3 ○ $\frac{4}{1}$ 4	
14	321 ○ 4		30	31 ○ 24	
15	34 ○ 12		31	2 ○ $\frac{3}{1}$ 4	
16	431 ○ 2				

The circle (○) represents Jupiter; ⊙ signifies that the Satellite is on the disc; ● signifies that the Satellite is behind the disc or in the shadow. The numbers are the numbers of the Satellites.

SATURN:—

Date.	Right Ascension.	Declination.
	h. m.	
July 1 ...	3 0	N 14° 47′
,, 16 ...	3 6	15° 6′
Aug. 1 ...	3 10	N 15° 21′

Saturn rises E.N.E. on July 1st at 1 a.m., and on August 1st at 11.5 p.m. The planet is situated in Aries, and will be more favourably placed for observation during the next few months than he has been for many years past.

The ring, as seen in the telescope, appears well open, the apparent diameter of the outer major axis being 40″, and of the outer minor axis 15″; the southern surface of the ring is visible, and inclined to our line of vision at an angle of 22°.

URANUS:—

Date.	Right Ascension.	Declination.
	h. m. s.	
July 1 ...	20 1 28	S 21° 5′ 33″
Aug. 1 ...	19 56 21	S 21° 20′ 15″

Uranus rises in the S.E. at 9.20 p.m. on July 1st and at 7.12 p.m. on August 1st. The planet is in opposition to the Sun on the 21st, hence about this date he appears due South at midnight; he is describing a retrograde or westerly path, about 2° S.E. of σ Capricorni and can just be discerned with the naked eye on a very clear night. The planet's remarkable spectrum of broad dark bands is well worth the attention of observers, even though they possess only small instruments.

NEPTUNE:—

Date.	Right Ascension.	Declination.
	h. m. s.	
July 1 ...	7 29 33	N 21° 16′ 20″
Aug. 1 ...	7 34 23	N 21° 6′ 2″

Neptune is not observable this month, being in conjunction with the Sun on the 14th.

METEOR SHOWER.—The most notable shower in July is that of the δ Aquarids, which occurs on the 28th. The radiant is situated in R.A. $22^h\ 36^m$, Dec. S. 11°, and the meteors are slow, with long tails.

The Perseid shower also commences about the 10th, the radiant being initially near ο Cassiopeiae.

Mira (ο Ceti) was due at maximum on June 30th, but as the exact date is somewhat uncertain, observations of magnitude should be made for some time after this date. The mean period is about 331 days. The star is also remarkable for its spectrum, which may be well observed in a three-inch telescope, using a Maclean or Zollner spectroscopic eyepiece; the spectrum consists of broad dark bands, in which bright lines, due to hydrogen, occur.

TELESCOPIC OBJECTS (Double Stars, &c.):—5 Serpentis, XV.^{h} 13^m, N. 2° 13′, mags. 5·1, 10; separation 10″.

β Serpentis, XV.^{h} 41^m, N. 15° 44′, mags. 3·8, 10; separation, 31″.

θ Serpentis, XVIII.^{h} 51^m, N. 4° 4′, mags. 4·0, 4·2; separation, 21″·6. Both are yellow, the primary being paler than the smaller star.

ξ Cephei XXII.^{h} 1^m, N. 64° 8′, mags. 4·7, 7; separation, 6″.

δ Cephei XXII.^{h} 26^m, N. 57° 57′, mags. 4·2, 7; separation, 40″. A pretty pair for small telescopes, stars respectively yellow and blue. It is also a typical short period variable star, not of the Algol type, the period being $5^d\ 9^h$, with a sharp rise from minimum to maximum in $1^d\ 9\frac{1}{2}^h$.

Cluster in Libra, M 5. A compact cluster situated about one-third of a degree North of the double star 5 Serpentis; it appears like a large nebulous star when viewed with a pair of opera glasses.

Cluster in Serpens, N.G.C. 6633; about one-third of the way from θ Serpentis to α Ophiuchi. The cluster is visible to the naked eye.

XUM

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, D.Sc., B.A.

THE SUN'S DISTANCE DETERMINED FROM EROS.—Last year Mr. A. R. Hinks published the result of a very exhaustive discussion of the Sun's distance from the observations of Eros at the time of its near approach in 1900-1901. His final value for the Sun's parallax is $8''{\cdot}806$. Taking the Earth's equatorial diameter as 7925·45 miles, the Sun's distance is 92,831,000 miles, with a probable error of some 30,000 miles. This result is very close to that previously deduced by Harkness from a Least-Square adjustment of all available material, and also to Gill's result from the minor planets Iris, Victoria and Sappho. It is expected that Eros will in the course of years afford a much more accurate determination than any yet made, by the very large perturbations which the earth causes in its motion. Careful observation of these will give the ratio of the Earth's mass to that of the Sun, from which the distance of the latter readily follows. These perturbations can be expressed as a series of regular waves, or Sine-curves, of various periods. The largest wave has a period of 40·6 years, the amplitude of the Cosine part of it being $-\ 703''$, and the argument seven times Eros' Mean Longitude—four times that of Earth. There is another large term with amplitude $259''$ and multipliers of the longitudes 37 and 21; period 82·6 years. A more accurate knowledge of the period of Eros is required before this last term and others of longer period can be accurately calculated. Forty-six revolutions are so nearly equal to eighty-one years that it is still uncertain in which direction they differ. The shift in the planet's place due to these terms is increased by the eccentricity of the orbit, and by the fact that the planet is at times so near the earth that the heliocentric shift is increased sixfold. A total range of some 3° may thus arise, and as the range due to parallax is only $2'$ at most, it will be seen how much the method of perturbations will eventually surpass the other. It will probably not attain its full accuracy till two or three times the forty-year period have elapsed. But it is likely that before the Transit of Venus in 2004 the Sun's distance will be so well known that observations of the Transit will be useless for this purpose, and will simply be employed for correcting the elements of Venus' orbit. I have taken the above figures from a paper by Heinrich Samter in *Astr. Nach.*, No. 4498.

NEW DETERMINATION OF THE MOON'S DISTANCE.—During the last six years the small bright crater Mösting A has been regularly observed on the meridian both at Greenwich and the Cape. It is much easier to bisect the crater with a micrometer wire than to place it tangential to the Moon's limb, which is often serrated by mountains. About a hundred nights are available on which the crater was observed at both stations, and comparison of these has given a new determination of the Moon's distance. The chief source of uncertainty in the result is the fact that the shape of the earth is not yet known with great precision. The distance was accordingly computed on two assumptions of the shape, viz., compression $1/293\frac{1}{2}$ and $1/300$; these about cover the present uncertainty. On the first assumption Hansen's parallax (which is $57'\ 2''{\cdot}23$) needs a correction of plus $0''{\cdot}50$, and on the second of plus $0''{\cdot}12$. On the former assumption the Moon's distance comes out 238,817 miles. Another way of finding the distance is based on the observed period and the force of gravity at the Earth's surface. This method also gives results that vary, though to a less extent, with the Earth's figure. The deduced corrections to Hansen's parallax are $0''{\cdot}45$ and $0''{\cdot}36$ on the above assumptions. Hence to make the two methods agree we must take the compression as $1/294\frac{1}{2}$. This applies to the mean meridian of Greenwich and the Cape, for it is quite possible that it is sensibly different for different meridians. Sir David Gill has for many years been endeavouring to have South Africa geodetically connected with Europe, and only a few links are now needed to complete this great work, which would give a measured meridian extending from the North Cape to South Africa, and would give the compression of this meridian very accurately. It seems to me that it would be advisable for equatorial observatories to measure the moon's distance by the diurnal method (comparing observations made east and west of the meridian at the same station). The equatorial parallax of the moon would thus be given, free from uncertainty arising from the figure of the earth, and it would in addition be possible to test whether the equator has any ellipticity by comparing the results obtained at different equatorial stations. The measures might be made photographically, for Professor Pickering and Mr. H. N. Russell have lately shown that good photographs of the moon for position can be obtained by giving the surrounding stars a time exposure, the moon being screened by a disc except for a fraction of a second, the time of which may be automatically recorded. This plan is analogous to that used for many years at Greenwich for photographing Neptune and its satellite, and double stars that differ much in brightness.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

THE BIOLOGY OF LICHENS.—A vast amount of controversy has centred around the relationship between the two components of the thallus, or plant body, of the Lichens. A recent short paper by Tobler (*Ber. deutsch. bot. Ges.*, 1911) serves as a reminder that the question is by no means settled, and the following notes may be of interest to the student of plant life who knows something of the general characters of these curious organisms.

The Lichens form a quite exceptional group of plants, with various peculiar features. A Lichen is a compound plant, consisting of a Fungus individual and numerous Alga individuals. The Fungus, composed of branching and interlacing threads, has grown around the Algae, enclosing them in a sort of nest, in a manner which has often been compared to the enmeshing of a fly by a spider. The result is that the Lichen can grow in places which would be unsuitable for the independent existence of either the Fungus or the Algae of which it is composed. Algae grow in water or in moist places, and very few can live without a regular and abundant supply of moisture, while (apart from the leathery bracket-like forms) Fungi are very sensitive to cold and drought. Yet the Lichens thrive in the bleakest positions and in the most severe climates, as on bare mountain rocks where they may get no water for weeks on end, or may be soaked with rain and mist for equally long periods, and where they are exposed to great extremes of heat and cold.

In a typical Lichen the Fungus provides the organs of fixation; protects the Alga cells from drought and other injurious influences; absorbs water with dissolved salts, and air with carbon dioxide; and it alone produces the spore fruits. The Alga, on the other hand, manufactures organic food, with the help of light, from carbon dioxide and

water and salts, and it shares with the Fungus in producing the asexual brood bodies or soredia.

Both the Fungus and the Algae which make up a Lichen can, under suitable conditions, be induced to grow independently, though in the Lichen body itself they are mutually dependent upon each other. The isolated Alga cells grow and multiply when supplied with water, a few simple salts, and air containing carbon dioxide. The Lichen spores will germinate in a culture solution containing organic substances (sugar, and so on) and produce a small thallus which contains, of course, no Alga cells.

The reproduction of a Lichen is somewhat complicated, for we have to consider the processes of multiplication carried on by (1) the Alga cells, (2) the Fungus, (3) the Lichen as a whole. (1) The Alga cells increase in number by growing and dividing as if they were living independently, but do not bring about the reproduction of the Lichen as a whole. (2) In spore formation the Fungus alone is concerned, the spores being formed in special sac-like threads (asci) which develop from the Fungus web. The spores on being carried by the wind to a suitable place, germinate and, if the right Alga is at hand, the Fungus threads surround them and a Lichen thallus is woven. By sowing Lichen spores on plates on which minute Algae are growing, we can readily observe the production of a Lichen. In Nature, the Algae usually present in Lichens are widespread, so that the formation of a young Lichen thallus depends largely on the existence of suitable general conditions for growth. (3) Many Lichens are largely propagated by means of small brood-bodies (soredia), budded off by the thallus. Each soredium consists of a few Alga cells, or only one, surrounded by a web of Fungus threads. Sometimes these soredia are produced in definite clumps, but more often they form a powdery layer sprinkled over the thallus.

It must be remembered that the view of the symbiosis, or mutually beneficial partnership, relation between Fungus and Alga applies strictly only to the Lichens that grow on bare rocks and stones. In fact, even in these cases the Fungus proceeding from the germinating Lichen spore must be supplied with some organic substances derived from decaying plant or animal remains on the rock or stone. The Lichens that grow on ordinary soil, and on trunks of trees, resemble ordinary Fungi in being saprophytic—that is, they live at the expense of decaying organic matter, so far as the Fungus constituent is concerned. Moreover, many Lichens that grow on leaves in the Tropics, as well as some that grow on trunks, are more or less distinctly parasitic, drawing part, at least, of their nourishment from the living cells with which they are in contact by their underside or by their fixing and absorbing organs (rhizines).

As a matter of fact, various writers have maintained that the relation between the Fungus and the Alga in a Lichen is simply one of parasitism on the part of the Fungus. In some cases, the Fungus threads have been seen to penetrate the Alga cells instead of merely spinning an enclosing web around them, and the presence of dead Alga cells in various Lichens has suggested the view that the Fungus kills the Alga by means of ferments. Possibly the Fungus makes use of the Alga for some time after its spores have germinated, and then proceeds to live in the same way as an ordinary saprophytic Fungus when on a substratum rich in organic matter. This view is supported by the fact that Fungi which normally form part of a Lichen have been found growing independently, and there seems little doubt that in most Lichens the Fungus is capable of absorbing organic food from the substratum and is not dependent upon that which is manufactured by the Algae.

From the structure of the Lichen thallus it is clear that the Alga cells are placed in somewhat unfavourable conditions for the making of food by carbon assimilation. They are not at all well situated with reference to light and air, being covered by the thick dense cortical tissue which often contains various pigments and is thus darkened, while the compactness of the overlying tissue makes difficult the access of atmospheric air to the green cells. The latter difficulty is in many cases obviated by the presence of special canals and slit-like rifts in the cortex. In some of the *Parmelia* species, which have been carefully examined by Rosendahl (*Nova Acta Leop.-Carol. Acad.*, 1907) the cortex, elsewhere thick and consisting of dense tissue, shows at places a loose texture corresponding to the lenticels in the cork of tree stems, while in those species which have a thin and delicate cortex these lenticels do not occur. That lack of light and air tend to restrict the growth of the Algae is further shown by the fact that the usually continuous Alga layer is often interrupted below the fruits of the Lichen, and also below the places occupied by parasitic Fungi which are sometimes found growing on the surface of the Lichen thallus.

An interesting line of research in the physiology of Lichens is opened up by the striking results obtained by Treboux and other workers, with reference to the nutrition of the simpler Green Algae. It has been shown that many of these unicellular Algae can utilize organic acids (acetic, lactic, oxalic, and so on), as a source of carbon, light being unnecessary for the process, and that among the simple forms (*Pleurococcus* and others), which can obtain food in this way, the common Algae found in Lichens are included. These Algae, when supplied with organic acid solutions, can grow and develop in complete darkness. Lindau (*Lichenologische Untersuchungen*, 1895), noticed in a Lichen (*Pyrenula nitida*) that not only the Fungus threads but also those of the Alga, penetrated the bark of the tree on which the Lichen was growing, although the Alga (in this case a filamentous one belonging to the genus *Trentepohlia*) is only loosely bound up with the Fungus threads.

Tobler suggests that the Alga in a Lichen may utilise as its source of carbon organic acids which are formed as bye-products in the nutrition of the Fungus. It has long been known that oxalate of lime frequently occurs in crystalline masses and incrustations on the threads of the Fungus in Lichens, as well as on the threads of ordinary Fungi. In Lichens, the oxalate is never found associated with the Alga cells. Oxalate is also produced abundantly in cultures of isolated Lichen Fungi, even in cases where the Lichen itself is free from it. From his culture experiments, using the common yellow Lichen, *Parmelia parietina*, Tobler finds that (1) calcium oxalate is freely produced by the Lichen Fungus grown on gelatine; (2) on the other hand, developing Lichen plants on the same substratum, arising from the addition of the Algae to the Fungus, produce no oxalate; (3) fully developed plants of this Lichen, growing on bark, contain no oxalate; (4) in fluid cultures, containing no source of carbon excepting the carbon dioxide of the atmosphere, the Alga cells remain green and grow in the normal manner; (5) if the Lichen Fungus is also present in the culture the Algae become colourless, but continue to grow luxuriantly.

Many other facts support the view that the Alga in a Lichen may use the oxalic acid, and possibly other organic acids, produced by the Fungus. For instance, Rosendahl showed that in the brown Parmelias, thinness of the cortex and presence of oxalate of lime go hand in hand—evidently in such cases the Alga receives sufficient light to enable it to make food by photosynthesis, hence it does not use up the oxalate.

EVOLUTION OF THE FLOWER.—Wernham, in his second article on Floral Evolution, in the *New Phytologist*, (see "KNOWLEDGE" for June, 1911), deals with the Lower Dicotyledons (Archichlamydeae) in some detail, with special reference to their phylogenetic relations to the Higher Dicotyledons (Sympetalae or Gamopetalae). It is remarkable that whereas the flowers of barely twenty per cent. of the former have the stamens equal to or less than the corolla segments, this character is found in nearly ninety-five per cent. of the species of Sympetalae. Again, only about eighteen per cent. of the Archichlamydeae have a pistil composed of two syncarpous carpels, while in the Sympetalae fully seventy-five per cent. of the species have a bicarpellary pistil. The conclusion to be drawn is that the progressive tendency to economy of production, observable at work in the Archichlamydeae, has reached a high degree of realization in the Sympetalae, in

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which also we find higher adaptation to insect visits. In the Sympetalae, zygomorphy occurs in nearly fifty per cent. of the species, as against barely fifteen per cent. in the case of Archichlamydeae. Aggregation into dense inflorescences is the chief feature of the Compositae, an order which comprises over twenty-seven per cent. of the total number of Sympetalae, and, indeed, over ten per cent. of the sum total of flowering plant species.

The author then gives a summary of the various cohorts and orders of Archichlamydeae, tracing the evolutionary tendencies through this series. Taking first the essential organs—the androecium and the pistil—the general tendency to economy in production of parts is emphasized, and the question is raised, "To what extent has the working of the principle of economy been accompanied by the compensatory tendency of progressive adaptation to insect visits?" In this connection attention is called to the absence in Archichlamydeae of a strong tendency to *floral aggregation*, such as we find realized and expressed in the Compositae among the Sympetalae. Dense inflorescences occur in isolated cases throughout the Lower Dicotyledons, but aggregation does not characterize any relatively large group except one, the Umbelliflorae, in which the inflorescence unit is typically a close umbel. The general tendency to *zygomorphy* goes hand in hand with progressive aggregation, the outer florets tending to bilateral symmetry and especially to increased development of the corolla on the outer side. In the Lower Dicotyledons, however, the zygomorphy of relatively large and solitary flowers occurs only in isolated cases here and there, but does not form a critical character of any great group comparable with the Personales and Lamiales in the Sympetalae. Again, *fusion* plays a very inconspicuous part among the Lower Dicotyledons; a corolla tube is, of course, absent, though some specialised "apetalous" groups (*e.g.*, Proteales) have flowers with a typically gamophyllous perianth. In the Geraniales and the Papilionaceae, however, a tube is formed by the cohesion of the filaments of the stamens. But a far more extensive tube-forming tendency in the Archichlamydeae is that produced by means of the progressive hollowing of the flower receptacle.

In the higher families of Archichlamydeae, from the Buttercup cohort (Ranales) upwards, we find various stages of *perigyny*, leading to *epigyny*. The inferior position of the ovary may, however, have been produced in descent in other ways than by a gradually increasing degree of perigyny, though this method alone has left any continuous trace among existing plants. Whatever the evolutionary methods of its production may have been, the inferior position of the ovary conduces to economy in production, since in this way receptacular tissue can be pressed into the service of ovule protection and fruit formation. At any rate, it is certain that these floral types, such as the Compositae, which are admittedly in the van of evolutionary advance, invariably have an inferior ovary, while no epigynous flower can be called unquestionably primitive.

In attempting to find some phyletic connection between the Archichlamydeae and the Sympetalae, one can hardly suppose that the cohesion of the petals, which is the sole essential difference between the two groups, followed upon one line of evolution, nor that sympetaly originated at one point only of any particular line. That is, there is a *primâ facie* presumption that the Sympetalae are polyphyletic in origin, yet even if the series is composite it is also synthetic, in so far that its component members may be connected on the lines of certain well-marked progressive tendencies to biological advance. These tendencies do not differ fundamentally in any way from the tendencies seen at work in the Archichlamydeae, but they do differ in degree, as might be expected from the relatively high biological organisation of the group. The tendency to reduction of parts has already reached an advanced stage of realisation, and it plays a secondary rôle in the Sympetalae, in which the prominent factor is that of progressive adaptation to insect visits.

In the Sympetalae, the tendency to economy in production is expressed by (*a*) reduction of stamens to a number less than that of the corolla segments, following upon zygomorphy; (*b*) progressive reduction of the calyx to a pappus or to zero; (*c*) reduction of the carpels to two, the loculi to one, and the ovules to one.

The tendency in Sympetalae to progressive adaptation to insect visits is shown in (*a*) the general introduction to zygomorphy in Tubiflorae on the one hand and in Aggregatae and Campanulatae on the other, representing the two types of zygomorphy shown in Archichlamydeae; (*b*) the pollen presentation mechanism, a general feature of the Campanulatae and especially of the Compositae order.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

MEASUREMENT OF POLLUTION OF THE ATMOSPHERE.—Hitherto, the only chemical means of determining the degree of pollution of the atmosphere has been to estimate the proportion of carbon dioxide, and draw a deduction from the amount by which it exceeded the normal quantity. This method could only be regarded as giving approximate values, since carbon dioxide is one of the products of combustion as well as of respiration, and its estimation afforded an indication of the degree of ventilation rather than that of the vitiation of the air, which is due to the condensation of animal products of excretion.

An ingenious method of measuring these condensed products has been devised by MM. Henriet and Bouyssy (*Comptes Rendus*, 1911, CLII., 1180). It is based upon the fact that pure air always possesses oxidising properties, whereas excretory products are all reducing substances, and thus an estimation of the reducing property of a measured volume of the air is strictly proportional to the degree of pollution. The foreign bodies of organic origin to which pollution is due, are condensable simultaneously with the moisture in the atmosphere, and the method, therefore, consists of three steps:—(1) Condensation of a given volume of water from the atmosphere by means of a freezing mixture; (2) Calculation of the quantity of air corresponding to the amount of water condensed; and (3) Estimation of the amount of potassium permanganate solution reduced by the organic impurities in an aliquot part of the condensed moisture. The results are calculated into the corresponding quantity of oxygen, and expressed in milligrammes per one hundred cubic metres of air.

By this method the relatively pure air in the Montsouris Park, in Paris, gave a value of one, whereas the air in the vicinity of the Hôtel-de-Ville had a value of ten. A room in which several rabbits and monkeys had been kept gave the value thirteen, and the same figure was obtained with the air in a printing works. The figure fourteen was given by the air in a badly-ventilated office, and seventeen by that in a dark passage, while a dressmakers' work-room in which twenty people had been working all day with the windows closed gave the extremely high value of twenty-one. It seems probable that this method will prove a very valuable aid to the hygienic investigation of the air in closed places, such as submarine vessels.

BACTERIOLOGICAL STUDY OF HONEY.—An interesting investigation of the species of bacteria present within the cells of the honeycomb derived from different parts of France, has been published by MM. Sartory and E. Moreau (*Annales des Falsifications*, 1911, IV, 259). Among the bacteria of common occurrence in the air, which had been introduced by the bees into the cells, were the following species:—*B. subtilis*, *B. megaterium*, *Sarcina lutea*, *B. aërophilus*, and *Staphylococcus pyogenes*. There were also several mould-fungi and yeasts, including *Penicillium glaucum*, *Saccharomyces cerevisiae*, *Mucor racemosus* and *Aspergillus gracilis*. Among the bacteria was a golden yellow species, which secreted a bright yellow pigment soluble in absolute alcohol. It had a strong liquefying action upon gelatin, and differed in its biochemical characteristics from several very similar yellow bacteria. It appeared to be intermediate in its properties between the *Bacillus luteus* of Flugge and the *B. flavus* of Macé.

A NEW RADIUM PREPARATION.—An extremely active preparation of radium is now produced at the Neulenbach radium works, by means of a combined acid and alkaline fusion process, which extracts the radium directly from the minerals in the form of a crude sulphate. According to A. Fischer (*Chem. Zentralblatt*, 1911, I., 1190) it is possible by this means to treat ten thousand kilogrammes of pitchblende residues and obtain crude radium chloride from them within six weeks, while ores containing ten per cent. and less of uranium oxide, which hitherto could not be economically worked up, may now be used in the preparation of radium compounds. Preparations of radium showing an activity of upwards of three hundred thousand units (Mache) per 10 c.c. are now produced at these works. Experiments have shown that radium enters the human system chiefly by inhalation and not through the pores of the skin.

ARSENIC IN SEA-WEEDS.—It was shown by Gautier some years ago that arsenic was a normal constituent of certain marine algae, and this has recently been confirmed by MM. Tassilly and Leroide (*Bull. Soc. Chim.*, 1911, IX., 63). There are numerous secret medicinal preparations made from algae, including some of the anti-fat remedies, and experiments have shown that the whole of the arsenic will pass into these products. In addition to this, a small proportion of arsenic may be derived from impurities in the other ingredients of these remedies. The proportion of arsenic in marine algae and mosses of the same species varies but slightly, though there are considerable differences in the case of different species. The following results, expressed in milligrammes per hundred grammes of the algae, containing twenty to thirty per cent. of water, are typical of those obtained:—*Chondrus crispus*, 0·070; *Fucus vesiculosus*, 0·010; Corsican moss, 0·025; *Laminaria digitata*, 0·050; *L. saccharina*, 0·010; and *L. flexicaulis*, 0·010.

GEOLOGY.

By RUSSELL F. GWINNELL, B.Sc., A.R.C.S., F.G.S.

A GIGANTIC GEMSTONE.—A remarkable crystal of the precious beryl (a mineral which is known as emerald or as aquamarine, according to the particular shade of colour which it exhibits) was recently described in a paper read before the New York Academy of Sciences. This crystal, the largest beryl ever found, was discovered by a Turkish miner in a pegmatite vein in the State of Minas Geraes, Brazil.

The crystalline form was the usual hexagonal prism terminated at both ends by the basal plane. Although measuring 48·5 centimetres in length, the crystal was so transparent that it could be seen through from end to end when viewed through the basal termination. Its width was from forty to forty-two centimetres, and its weight 110·5 kilograms, or well over two hundredweight. It is estimated that the crystal would furnish at least two hundred thousand carats of aquamarine gems of various sizes, when cut. Twenty-five thousand dollars is said to have been paid to the finder for the stone.

For comparison with this gemstone, it may be interesting to recall the figures for some celebrated diamonds. The *Koh-i-Nur*, when brought from India, weighed one hundred and eighty-six carats (about one and a quarter ounces) and now, after recutting, weighs one hundred and six carats. Brazil produced the *Star of the South*, weighing two hundred and fifty-four carats when cut, but while holding the record for beryls, Brazil is easily surpassed by South Africa in diamonds. Thus the *Stewart* weighed two hundred and eighty-eight carats and the *Porter Rhodes* no less than four hundred and fifty seven carats (about three ounces) when found. But all previous records were beaten when, in the newly-discovered Premier mine in the Transvaal, the *Cullinan* diamond was found in the yellow ground, in 1905. More than three times the size of any known diamond, this stone weighed three thousand and twenty-five and three-quarter carats, or one-and-a-third pounds, and was clear and water-white throughout. The largest of its surfaces appeared to be a cleavage plane, so that it might be only a fragment of a much larger stone. Purchased by the Transvaal Government in 1907, the *Cullinan* was presented to King Edward VII. It was cut, in Amsterdam, into nine large stones and a number of smaller brilliants.

THE GREAT PROVINCES OR BRANCHES OF IGNEOUS ROCKS.—The old system of grouping the whole assemblage of igneous rocks along one line of variation, from *acid* through *intermediate* to *basic*, is gradually giving way to a more complex, but apparently more natural, system. In "The Natural History of Igneous Rocks" Harker states that we shall make a decidedly closer approach to the facts if we assume, not one, but two main lines of variations. Each line may be conceived as spanning the interval between the basic and acid extremes, the two diverging most widely near the middle of their course. These great provinces or branches are spoken of as the "Atlantic" or "alkalic" group and the "Pacific" or "sub-alkalic" group. These two great branches of igneous rocks have a well-marked areal distribution, and define two petrographical regions of the first order of magnitude, which stand in relation to the grandest tectonic features of the globe.

Although in the main the Atlantic type of rocks occur towards the Atlantic sea-boards both in the American continent and the Eurasian continent, and the Pacific type towards the Pacific sea-board, yet many exceptions occur. Moreover, in a country like Patagonia, where the Pacific and Atlantic Oceans come near together the types are curiously interwoven, as in the case cited below.

In a recent paper, also dealt with below, there is established a third "natural family" of igneous rocks, the *spilitic suite*, which is clearly distinguished from the Atlantic and Pacific suites.

In the *American Journal of Science* for May, Professor L. V. Pirsson refers to "Geologisch-petrographische Studien in der Patagonischen Cordillera; von P. D. Quensel."

Travelling from Cape Horn northwards along the chains of the southern Andes the author throws much light on the geology of this little-known region.

A feature of interest to petrographers is the occurrence, at a number of places, of alkalic rocks. These consist of intrusive masses of essexite in stocks, exposed domes, and so on. These rocks are composed of purple pleochroic titaniferous augite, brown barkevikite, labradorite and analcite, the latter regarded as secondary, perhaps after nepheline. They are accompanied by a series of dykes of bostonite and camptonite with essexite porphyry, and the author parallels the occurrences with those of Southern Norway, made classic by the researches of Brögger. In other places aegirine-granite-porphyry is found with the essexite. The occurrence of these alkalic types in the sub-alkalic province of the Andes is interesting.

In the *Geological Magazine* for May and for June, 1911, Messrs. Dewey and Flett deal with "British Pillow-Lavas and the Rocks associated with them." These pillow-lavas are a group of basic igneous rocks, occurring only as submarine flows and very frequently exhibiting "pillow-structure." The term "spilite" is used to designate these lavas, which are found among Carboniferous, Devonian and Ordovician rocks in Devon and Cornwall. A great variety of types are comprised in the family, and they range from ultra-basic picrite to such acid extremes as quartz-keratophyre, soda-felsite and albite granite. The essential characteristics of the family are the abundance of soda-felspar and the remarkable frequency with which they have been albitised. The albitisation is not due to weathering or to shearing, but it may be grouped as a post-volcanic or juvenile change, produced soon after solidification of the rock. Like the Atlantic and Pacific igneous suites the spilite group has an intimate connexion with certain types of geological conditions. They are essentially rocks of districts that have undergone a long continued and gentle subsidence, with few or slight upward movements and no important folding.

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METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

THE weather of the week ended May 20th, as presented in the Weekly Weather Report of the Meteorological Office, was rainy at first, but became dry, though mostly dull.

Temperature was above the normal in all districts, the greatest excess being in the Midland counties, where the mean was 3°·6 above the average. The highest readings recorded were 73° at Norwich, and 72° at Raunds and at Southampton. In Ireland, N. the maximum did not exceed 66°. The lowest of the minima were 33° at West Linton on the 17th, and 34° at Balmoral on the 16th. Slight frost was recorded on the grass at several stations, the lowest reading being 29° at Markree Castle, Co. Sligo.

Rainfall was in excess in Scotland, E. and England, E., but was in defect elsewhere, very greatly so in various parts, many stations being rainless for the week. Sunshine was above the average in Scotland, W. and Ireland, N. and was normal in Ireland, S. In all other districts it was in defect. The least sunny district was the Midland Counties with a total duration of only 19 hours (17%) while the most sunny was Scotland, W. with 56 hours (50%). The sunniest station was Castlebay, Isle of Barra, which reported 70 hours of sunshine (61%).

The mean temperature of the sea-water round the coast ranged from 55°·4 at Teelin and Seafield to 45°·8 at Scarborough. Thunderstorms were reported at several stations, and during the early part of the week there was much mist or fog on the coast.

The week ended May 27th was unsettled, with thunderstorms and very heavy rains during the latter part. Temperature was again above the normal in all districts, that with the greatest excess being England, N.E., where the mean was 5°·7 above the average. The highest reading reported was 81° at Shaftesbury on the 27th. In Ireland, N., the maximum was only 66°. At Greenwich it was 78°. The lowest minima for the week were 29° at Balmoral and 30° at Llangammarch Wells. On the grass the minimum fell to 24° at Llangammarch, and to 25° at Crathes and at Greenwich.

In spite of very heavy local falls, the week's rain-fall was below the average in all districts, and at many stations the week was rainless. In England, E., the total for the week was only 0·01 inch as compared with an average of 0·44 inch. The thunderstorm rains towards the end of the week were very heavy and caused floods in many places. At Great Billing, Northants, as much as 2·0 inches fell in one day, and at Bere Alston, Devon, 2·5 inches was collected in one-and-a-half hours.

Bright sunshine was in excess in most districts, but in England, S.E., and Ireland, N., it was normal; while in Ireland, S., it was slightly below. The sunniest district was the English Channel with a total duration of 73 hours (68%) while the sunniest station was St. Mary's, Scilly, with 83·3 hours (76%). At Westminster the total duration was 42·2 hours (38%). The temperature of the sea-water ranged from 44° at Scarborough to 58° at Scilly and Seafield.

During the week ended June 3rd, the weather was fine and bright, but with many thunderstorms.

Temperature continued much above the average, and the mean values in most cases were higher than any recorded in the corresponding week during the last thirty years. The highest reading was 83° which was recorded at Fort William, Balmoral and Aspatria. At several other stations readings of 80° or upwards were reported. The lowest of the minima were 34° at Markree Castle on the 28th, and 35° at Balmoral on the 29th, the same day as that on which the maximum reached 83°.

On the grass, frost was experienced in Scotland, E., and Ireland, N., the lowest reading being 28° at Markree Castle. Rainfall was deficient nearly everywhere, and at quite a number of stations the week was rainless. Some very heavy thunderstorm rains were, however, reported, 0·92 inch at Rothamsted, 1·00 inch at Greenwich, and 2·86 inches at Epsom. Of this latter amount 2·44 inches fell between 5.20 p.m. and 6.10 p.m., on May 31st.

Sunshine was above the average at each of the reporting stations. The sunniest district was England, N.W., where the mean was 90 hours (79%), while the sunniest stations were Newton Rigg, near Penrith, 97·4 hours (84%), Stornoway 96·8 hours (80%) and Rhyl 96·7 hours (85%). At Westminster the total duration was 73·9 hours (66%). The temperature of the sea-water was higher than usual, except on the South-West coast of England. The individual readings ranged from 47° at Aberdeen to 62° at Seafield.

The weather during the week ended June 10th continued very fine generally, though thunderstorms occurred in many parts.

Temperature was still much above the average, an excess being reported from every station. England, S.W., was the district with the highest mean temperature, 61°·8, as compared with the average for the same district during twenty-five years of 55°·8. The highest of the maxima were 84° at Fulbeck, Lincolnshire, and Greenwich, with 83° at Tottenham, Westminster and other places. The lowest of the minima were 34° at Llangammarch Wells, and 35° at Newton Rigg, Blackpool and Glencarron. In nearly every case the lowest reading was recorded on June 10th. In the Channel Islands the minimum did not fall below 52°. Frost was still experienced on the ground, readings as low as 25° being reported at Llangammarch and Burnley, with 27° at Southport and Wisley. Rainfall was in defect in all districts except the English Channel, where the excess was due to a thunderstorm rain on June 8th, which in Guernsey yielded between 1·1 inches and 1·7 inches. In very many places (eighty-one stations out of a total of one hundred and seven stations) the week was rainless. Bright sunshine was in excess in all districts, especially in the South of England and the West of Scotland, where the mean total for the district amounted to 86 hours. The stations reporting the greatest duration were Brighton 99·8 hours (88 %) and Pembroke, 98·5 hours (86 %). At several other stations totals exceeding 90 hours were recorded: Tenby 95·5 hours (84 %), Douglas 94·4 hours (81 %), and Worthing and Eastbourne 93·5 hours (83%). At Westminster the total was 76·4 hours (68 %).

The sea temperature was much higher than in the corresponding week of last year, and ranged from 49° at Lerwick to 67° at Seafield.

MICROSCOPY.

By A. W. SHEPPARD, F.R.M.S.,

with the assistance of the following microscopists:—

ARTHUR C. BANFIELD.
THE REV. E. W. BOWELL, M.A.
JAMES BURTON.
CHARLES H. CAFFYN.
ARTHUR EARLAND, F.R.M.S.
RICHARD T. LEWIS, F.R.M.S.
CHAS. F. ROUSSELET, F.R.M.S.
D. J. SCOURFIELD, F.Z.S., F.R.M.S.
C. D. SOAR, F.L.S., F.R.M.S.

CYTOLOGY OF THE BACTERIA.—In the current number of the *Quarterly Journal of Microscopical Science*, Vol. 56, pages 395–506, appears an important paper on the above subject by C. Clifford Dobell. The author's main object has been to decide the question, whether or not the bacteria are nucleate cells. In making the investigations detailed in the paper the author selected certain large bacteria found in the intestines of some animals; they belong to four different groups, namely, cocci, bacilli, spirilla and the so-called "fusiform bacteria." The method of preparation described as the "drop" method, is said to be applicable also to small infusoria and other protists. A drop of the material to be examined is taken up on a platinum loop and placed on a slip, by its side is placed another drop of one per cent. Osmic acid or formol (forty per cent. solution of formaldehyde). These two drops are intimately mixed and spread in a thin film. When dry, no heat being applied for that purpose, the film is treated with absolute alcohol—this is necessary in the case where formol is employed as formaldehyde fixes protoplasmic structures without precipitating them in an insoluble form.

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From the facts detailed in the paper the author deduces the following chief conclusions :—

All bacteria which have been adequately investigated are—like all other Protista—nucleate cells. The form of the nucleus is variable, not only in different bacteria, but also at different periods in the life-cycle of the same species.

The nucleus may be in the form of a discrete system of granules (chromidia); a filament of variable configuration; in the form of one or more relatively large aggregated masses of nuclear substance; of a system of irregularly branched or bent short strands, rods or networks; and probably also in the vesicular form characteristic of the nuclei of many animals, plants and protists. There is no evidence that enucleate bacteria exist. Finally, in addition to these purely morphological conclusions concerning the nucleus, the author thinks it is highly probable that the bacteria are in no way a group of simple organisms, but rather one displaying a high degree of morphological differentiation, coupled, in many cases, with a life-cycle of considerable complexity.

THE GENUS *POLYTREMA* (FORAMINIFERA).—At the meeting of the Linnean Society, held on May 4th, Professor Sydney J. Hickson, F.R.S., communicated a revision of the above genus. The discovery of some very large specimens of Foraminifera belonging to the species described by Carter as *Polytrema cylindricum* in the material collected by Professor Stanley Gardiner in the Indian Ocean, led the author to make a careful examination of this and of other species attributed to the genus *Polytrema*. The result of this examination was to prove that the specimens usually labelled *Polytrema* in collections may belong to three quite distinct genera.

Polytrema cylindricum of Carter is the type of a genus for which the generic name *Sporadotrema* is proposed. The specimen described by Carpenter under the name *Polytrema rubra* Lamk., and many others that are labelled *Polytrema miniaceum* Pallas, in collections, belong to another genus for which the generic name *Homotrema* is proposed. The specimens described by Merkel, Lister and others under the name *Polytrema miniaceum* belong to a genus distinct from the other two, and for this it is proposed that the generic name *Polytrema* be retained.

A description of the principal characters separating the three genera is given in the paper.

As regards the geographical distribution of the three genera, it may be observed that *Sporadotrema* has only been found in the Indian Ocean and on the Macclesfield Bank in the China Sea, that *Polytrema* and *Homotrema* appear to have a much wider distribution in temperate and tropical seas, but at present the author has not seen any specimens of *Polytrema* from the shores of the American continent, nor has he seen any specimens of the genus *Homotrema* from the Mediterranean Sea.

COCCIDIOSIS IN GROUSE.—In an interesting paper contributed to the current number of *Science Progress*, Vol. V., pages 565-583, on the diseases of Grouse, Professor Arthur E. Shipley, F.R.S., describes the complex life history of *Eimeria* (*Coccidium*) *avium*, one of the seven distinct unicellular or protozoan parasites which live either in the intestines or in the blood of the grouse.

The chief source of contamination on the moors is the droppings of other diseased grouse. The droppings contain thousands of cysts (oöcysts) or spores of the parasite and these spores, with their hard coats, are extremely resistant and can endure for very long periods without the death of their contents, which gradually divide to form four smaller spores (sporocysts) inside. The spores are scattered over the moors by the action of the wind and rain and, alighting on the heather or in the tarns of the moors, are taken up by the grouse in their food or drink. When the cysts are swallowed, they enter the gizzard of the bird and pass unchanged into the first part of the intestine, called the duodenum. Here the pancreatic juice is poured into the intestine, to aid in digestion, and under its influence the cyst-wall is softened and dissolved, and the four small spores (contained within the ripened spore or oöcyst) are set at liberty. Each small spore contains two active motile sporozöites, which emerge from the softened spore-case and proceed to penetrate the epithelium of the duodenum. The young parasites ultimately cause the destruction of the lining of the first part of the small intestine—the region where, normally, the most active digestive processes occur. The *Coccidium* parasities multiply in the duodenal epithelium and then invade the caeca or "blind-guts," with disastrous results.

Sooner or later a limit is reached, on the one hand, to the power of the grouse chick to provide nourishment for the parasites, and on the other to the multiplicative capacity of the parasites themselves. The *Coccidium* then begins to reproduce sexually. Many small male parasites are produced, together with larger food-containing female *Coccidia*. The male and female parasites conjugate and then encyst, bursting through into the cavity of the gut and giving rise to the spores found in the caecal droppings on the moors.

PROTOZOA OF THE SOIL.—At the meeting of the Royal Society held June 1st, 1911, a paper was read by T. Goodey forming a contribution to our knowledge of the protozoa of the soil.

It gives an account of work carried out on the soil protozoa which are considered to be chiefly instrumental in limiting the activity of bacteria in the soil and thus in helping to render the soil comparatively infertile. Methods of obtaining protozoa in cultures of soil are described, and a list of the different species found so far is given. An experimental method for quickly finding the earliest ciliated protozoa occurring in a soil culture is described, in which use is made of the galvanotactic response which many of the protozoa show when stimulated by means of a continuous electric current. By means of this method, active ciliated protozoa have been found in from 1½ hours to 4 hours.

Experiments on the length of time required for a ciliated protozoon *Colpoda cucullus* to develop from its resting cysts have also been conducted in similar media and at the same temperature as used in the soil cultures. It has been found that the times required for development in both soil and cyst cultures are comparable, and that the first *Colpoda cucullus* to occur in soil cultures are almost identical in appearance with those which emerge from resting cysts.

The conclusion drawn from the experiments is that the ciliated protozoa are only present in the soil in the encysted condition, and do not, therefore, function as the factor limiting bacterial activity in the soil.

The protozoa of the soil are referred to in a paper by Dr. H. B. Hutchinson (see "KNOWLEDGE" N.S. Vol. VIII, pages 123-126.

QUEKETT MICROSCOPICAL CLUB.—May 23rd, 1911. Dr. E. J. Spitta, F.R.A.S., F.R.M.S., vice-president, in the chair. Mr. C. D. Soar, F.L.S., F.R.M.S., read a paper on "The work of the late Saville-Kent on British Hydrachnids." Together with Mr. Williamson, of Edinburgh, the author is preparing a monograph of British Hydrachnids, and had obtained from the British Museum (Natural History) Authorities permission to examine all the slides, notes and drawings which Mr. Saville Kent had brought together. The collection was begun in 1867. Mr. Soar found it possible to identify forty species from the mounted preparations, and a further ten from various notes and drawings. A detailed list of the species identified is added to the paper.

A paper by Mr. E. M. Nelson, F.R.M.S., on "Methods of Illumination" was read by the honorary secretary. Mirror illumination was first dealt with. The proper way to centre a concave mirror is:—First focus the object, then, looking *at* the eye-lens, by moving the mirror, bring the image of the light source central in the Ramsden disc. It is better to have centred illumination even at the expense of an incompletely lighted field. The use of ground glass then received attention, and surprise was expressed at the appreciative remarks made by Dr. Carpenter and Lewis Wright in their well-known books, when discussing the use of this medium. After exhaustive trials of ground-glass, and particularly in relation to its effect

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on the image, Mr. Nelson summed up the result by one word —"Fog."—The simplest condenser, even a single lens so used, gave a better image than could be obtained with ground-glass.

Sir D. Brewster, in 1836, was the first to employ colour screens in microscopy. Mr. Nelson recommended the use of a screen composed of a piece of peacock-green glass combined with a very light blue for visual daylight work, and for lamp-light a piece of thicker peacock-green glass combined with a blue glass of the tint of the blue cornflower. Reference was also made to the various forms of Gifford's screen and to that used by Dr, Miethe.

One other form of illumination dealt with by Mr. Nelson is that of using part of the spectrum. A prismatic spectrum is brighter than that given by a diffraction grating, although on the other hand, the dispersion obtained with a fourteen thousand line grating between E and G in the first order is more than double that of an ordinary flint-glass prism.

The Chairman in asking the meeting to pass a very hearty vote of thanks to Mr. Nelson, made some very appreciative remarks on the "M" series of screens issued by Messrs. Wratten and Wainwright. He considered them almost indispensable to the careful worker, as they afforded full control of the colour of the lighting and consequently of the amount of contrast obtained with all classes of coloured objects.

THE ROYAL MICROSCOPICAL SOCIETY.—May 17th, 1911, H. G. Plimmer, Esq., F.R.S., President, in the chair. Mr. J. E. Barnard made a communication on a method of disintegrating bacteria and other organic cells. The author first mentioned that bacterial toxins were of two kinds, extra-cellular and intra-cellular. The former were excreted into the medium, *e.g.*, beef broth, in which the organism was cultivated, so that by a process of filtration the organism could be removed and the toxin was obtained in the filtrate, but the majority of pathogenic micro-organisms did not excrete their toxins, at least to any great extent, and the toxins were retained within and formed integral parts of the cells of the organisms.

One method of obtaining these toxins was to mechanically disintegrate the bacterial cell, so that the cell contents were expressed, and the apparatus described accomplished this.

It consisted essentially of a containing vessel in which, by a suitable rotation of steel balls, the organisms were crushed.

The principal conditions to be fulfilled in such an appliance were:—

(1) Approximately every cell should be brought under the grinding action.

(2) Little or no rise of temperature should take place.

(3) The disintegration should be carried out in a vessel which was sealed so that, when dealing with pathogenic organisms, none could escape at any stage of the process.

These conditions were, in the main, complied with in the apparatus described. Experiments indicated that by this method the cell juices were obtained unaltered, and so were suitable for investigation on the chemical composition and properties of the bacterial proteins and other cell constituents. Also that, after the grinding process had been carried on for a sufficient time, practically no cells remained which could be properly stained by any recognised bacteriological method, and which, therefore, could be regarded as whole cells containing a normal quantity of cell juice.

Mr. James Murray presented a third portion of his report on the Rotifera observed by the Shackleton Polar Expedition of 1909, dealing with the new species, and so on, from the Pacific Islands. He said that in Fiji fifteen Bdelloid Rotifera were collected, in Hawaii twenty-four, ten species being common to the two groups of islands.

In Fiji two new species were dislinguished, *Callidina pacifica* and *Habrotrocha nodosa*, the latter previously known, as a variety, in India, and elsewhere.

In Hawaii there were no peculiar species, but some very distinct varieties.

In the various Pacific Islands there have been recorded thirty-one species of Bdelloids.

The attention of the Fellows of the Society was then directed to the collection of specimens of Pond Life, which had been arranged for the evening.

ORNITHOLOGY.

By HUGH BOYD WATT, M.B.O.U.

THE DISTRIBUTION OF THE NIGHTINGALE IN GREAT BRITAIN DURING THE BREEDING SEASON.—Discussion of this subject is revived by an article contributed to the June number of *British Birds* (Vol. V., No. 1, pages 2-21), by Mr. N. F. Ticehurst and the Rev. F. C. R. Jourdain. The chief value of the paper lies in the carefully worked out details given under those counties in which the distribution of the species is local, or which mark the limits of its range in England and Wales. This faunistic information is very valuable and full, and summarises present-day knowledge on this part of the subject, making clear the well-known and curiously partial character of the bird's distribution. Commenting on the last-named point, the writers express the opinion "that the real obstacles which prevent the general distribution of this species over the greater part of England and Wales are the ranges of elevated land, which it instinctively avoids." This seems adequate only in so far as it is limiting and negative in character, and the condition laid down is in no way peculiar to the Nightingale. Height of land is a factor which affects the distribution of species generally, but many other considerations come in. That the Nightingale is not found on elevated land, and that its distribution is restricted or limited by such elevations, may account for its absence there; but this reason seems an incomplete explanation of its presence in its frequented haunts and known stations, and not in contiguous places where the conditions are apparently similar. It would seem that Professor Newton's judgment must still stand, viz.:—"No reasonable mode of accounting for the partial distribution of the Nightingale has hitherto been propounded" ("Dictionary of Birds," 1903-6, pages 339-340).

THE BIRDS OF ST. ALBANS.—This famous old city, like the county in which it is situated, has rather a meagre avi-fauna, due, chiefly, to the absence of maritime conditions. Nor does there seem to be any great fly-line of migrants across the county from which records might be gathered. Hertfordshire birds number about two hundred and ten species in all, and the St. Albans list includes one hundred and twenty-eight of these. Mr. W. Bickerton gives a good account and classification (for the city and a radius of five miles around) in a work entitled "St. Albans and its Neighbourhood" (1911), published by the Hertfordshire Natural History Society, in connection with the Annual Congress of the South-Eastern Union of Scientific Societies recently held in that city. Mr. Bickerton's article (pages 240-243) lays a sound basis for further observations and bird-study in the district.

ACCOUNTING FOR THE ROOK.—The thinning-out of the Rook, recommended by some authorities, is not neglected in some districts. For instance, Mr. C. C. Ellison, Bracebridge, Lincoln, writes to *The Field* that one day's shooting each year for thirty years on the same estate has produced 20,793 Rooks. The biggest bag was 1,220 to seven rifles; the best was 1,210 to two rifles only. Mr. Ellison adds that there are probably not half the Rooks in the country now that there were in 1880.

THE BOYD ALEXANDER COLLECTIONS.—The great collections formed by the late Mr. Boyd Alexander on his African expeditions, and bequeathed by him to the Natural History Museum, South Kensington, have now been handed over to that institution by his executor, Mr. Robert Alexander. They comprise nearly four thousand bird-skins of African species, and include the type-specimens of no fewer than eighty species.

ANTARCTIC BIRDS.—The Scottish National Exhibition, now open at Glasgow, contains a section illustrating the Antarctic Expedition of the "Scotia." There is a good display of the birds and seals of the Antarctic, shown in artistic representations of their natural surroundings. One of the cases represents a scene in the South Orkneys, and conveys a vivid impression of Antarctic bird life. Five species of penguins, with eggs and young, are represented. Notably there are three Emperor penguins, standing in solitary state on an ice floe, one of them trumpeting a love-song to his mate. Among the smaller birds, the most prominent are black-throated or adelia penguins. A pair are seen hurrying back to their nests after having had an excursion to sea in search of food. An anxious mother is seen feeding her young, while another pair sit expectant alongside an unhatched egg. There are also the gentoo penguins, with red-marked bills and white-striped heads; the macaroni penguin of the golden crest, and the ringed penguin.

Twelve other species of Antarctic birds are represented. These include the blue-eyed shag, in its nest of seaweed; the Dominican gull, resembling the black-back gull of our own waters; and the fierce skuas fighting over the body of a penguin. The only land bird of the Antarctic, white and in form like a chicken, is also shown. Then there are the petrels, —the giant petrel, sitting on its nest of stones; the silver petrel, the Antarctic petrel, the blue petrel, and the snowy petrel, whose presence is indicative of the ice pack. There is a fine specimen of the mottled black and white Cape pigeon, whose eggs the "Scotia" naturalists were the first to discover, although the bird has been known for at least three hundred years.

PHOTOGRAPHY.

By C. E. KENNETH MEES, D.Sc., F.C.S., F.R.P.S.

THE FOGGING POWER OF DEVELOPERS.—A paper on this subject appears in the June number of the *Photographic Journal*. It is, of course, well known that developers differ in the amount of fog which they produce on unexposed plates, but this appears to be the first systematic attempt to compare the fogging power of different developers and to distinguish the conditions which tend to produce fog in development. In order to compare the fogging power of different developing solutions, it is necessary to measure the amount of fog which they will produce in the time necessary to produce a given degree of contrast.

In the development of an exposed plate, the rate at which density grows is usually expressed by what is called the "velocity constant," which quantity may be denoted by the symbol K. (See "KNOWLEDGE" "Notes," May, 1911.) The value of K for a given plate and developer is easily determined and if we can find some equally simple means of determining and expressing the rate at which fog grows in an unexposed plate, it is obvious that a comparison of the two constants should give an idea of the fogging power of the developer used.

For example, if the rate of growth of fog on an unexposed plate is exactly equal to the rate at which the density grows in exposed parts of the same plate, it is obvious that no image can result, the fogging power being so great that we can only obtain a uniform deposit over exposed and unexposed portions alike. A developer giving such a result will be useless, and it is in all cases necessary that the velocity of the fogging action shall be less than that of development.

If we express the fogging velocity by the symbol F, just as we express the developing velocity by the symbol K, then the ratio of F to K can be taken as a measure of the fogging power of the developer, and therefore we may measure F and K separately, and then, dividing F by K, obtain a quantity which can be used as a measure of the fogging power.

In the production of measurable degrees of fog on unexposed plates very considerable duration of development was necessary and, as any oxidation of the developer affected the results, the plates were developed in a tube which was quite full of developer, a rubber cork fitted with a stop-cock being pushed in until the developer spurted out from the stop-cock, which was then closed. In order to avoid temperature errors, the tube was a vacuum-jacketed Dewar tube.

The developer used was Hydroquinone and Caustic Alkali and the results obtained showed that the fogging power of such a developer is mainly due to two causes—oxidation products of the developer itself, and the sodium sulphite used as a preservative. The fogging power of non-oxidised developers not containing sulphite was independent of the amount of alkali present, increase of the alkali increasing the development of both exposed and unexposed bromide in the same proportion, leaving the ratio unaltered.

The oxidation product of the hydroquinone developer, quinhydrone, was found to be a powerful fogging agent in the presence of alkali, developing exposed and unexposed bromide at the same rate and consequently developing no image on an exposed plate. Since this compound cannot exist in the presence of sodium sulphite ordinary photographic developers do not give oxidation fog! But sulphite itself is a source of fog, the amount of fog depending on the concentration of the sulphite and rising to a maximum at a low concentration, decreasing again as the concentration is increased.

The explanation given by the authors for the phenomena described by them is based on a discussion of the reduction potential of developers.

The reduction potential of a reducer, or the oxidation potential of an oxidiser is the analogy for chemical affinity of electric potential in electricity.

On the other hand, the resistance potential of a chemical substance (*e.g.*, silver bromide) may be compared to the "back potential" of an arc lamp. It requires a certain voltage (about forty volts) to enable an arc with carbon poles to burn, and if the potential of the source of electric energy is lower than this, then the arc will not burn.

If iron poles are used in the arc a higher potential (about sixty-five volts) is required to enable the arc to burn; so that there is a range of voltages (from forty to sixty-five volts) where carbon arcs can burn but iron arcs cannot.

The authors suggest that the difference between fogging agents and developers is analogous to this difference between the voltages, which will work arc lamps with different poles. A substance with a low reduction potential (*e.g.*, neutral hydroquinone) cannot reduce either exposed or unexposed silver bromide. If the reduction potential is higher then exposed silver bromide becomes developable, but the resistance potential of unexposed silver bromide is still too high. All substances which have reduction potentials higher than the resistance potential of exposed silver bromide, but lower than that of unexposed silver bromide will be developers. If the reduction potential of a substance is higher than the resistance potential of unexposed silver bromide (as is the case with alkaline quinhydrone, for instance) then it will be a fogging agent.

Any substance which tends to lower the resistance potential of unexposed silver bromide will increase the fogging power of a developer, and, since the resistance potential of a substance depends upon its insolubility, any substance, such as sulphite, which increases the solubility of silver bromide will increase the fogging power of a developer, while a substance, such as an alkaline bromide, which decreases the solubility will decrease the fogging power.

The subject would seem to require a good deal more investigation and probably the theory outlined above will require much modification, but it is satisfactory that some progress is being made with a subject about which so little has hitherto been known.

PHYSICS.

By A. C. G. EGERTON, B.Sc.

PHYSICISTS have had the opportunity of examining the fruit of each other's work during the past month. The Physical Society has enjoyed the opportunity of visiting the National Physical Laboratory; while the Conversazione of the Royal

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Society, on May 10th, included exhibits of very great interest. Further than this, many illustrious men from foreign countries have honoured their scientific cousins with their presence in this country, strengthening thereby the absolute internationality of science. Among these one may mention Professor Svante Arrhenius, Professor Richards and Professor Wood. It will be well this month to note shortly a few of the contrivances which have thrown light on the subjects recently investigated.

Professor Wood, in a lecture to the Royal Institution, on Friday, May 19th, described many experiments which he has made on ultra-violet light. Using quartz lenses and silvering them with a uniform coating of silver, he has been able to photograph objects by ultra-violet light; the silver absorbs all the visible light. In such photographs the sky is very bright; the ultra-violet iight gets scattered by the atmosphere to a very great degree, so much so that no shadows appear. Many quite white bodies, such as Chinese white and most garden flowers, do not reflect ultra-violet light, and so appear black. Professor Wood has photographed the moon by ultra-violet light, and obtained patches which show exceptional absorption. To exhibit this, he had recourse to the ingenious method of projecting two photographs on to a screen so that the two images were completely in register and superposed. The one photograph is taken by ultra-violet light, the other by ordinary light. A red filter is placed in front of one photograph and a green in front of the other, so that any difference in the two is at once detected by a preponderance of red or green light on the screen, instead of a complete neutralisation of the two complementary colours. With infra-red light there is no scattering by the sky, which appears quite black in photographs taken through a screen of cobalt glass and certain organic dyes which cut off all light of shorter wave-length than λ 6800. But the leaves of trees reflect this deep red light almost completely. These effects were dealt with more completely by Dr. Mees in "KNOWLEDGE" a few months back.

Professor Wood has been able to isolate short ultra-violet waves from a magnesium spark by a system of quartz lenses. The centre portion of one of the lenses is stopped out altogether, while the distance apart of the lenses is so arranged that the ultra-violet light alone can pass through the outer portion of the second lens, the more refrangible rays being stopped from passing by the centre blackened portion of the lens. There is another way of isolating the ultra-violet waves alone, but this latter method only obtains the more refrangible of these rays: those which can penetrate glass. A screen made of nitrosodimethylaniline combined with a cobalt glass attains this object.

Messrs. Wratten and Wainwright supply such light filters. Their list includes colour filters for many purposes, such as the isolation of the green mercury line; a screen which in combination with a mercury lamp gives an absolutely monochromatic beam. The balancing of the colours in the tricolour screens is very perfect and they should have many applications; the researcher, the lecturer, the photographer and the microscopist will find many uses for them.

Lord Rayleigh has pointed out that transparent objects are only visible when they are illuminated unequally. Kaufmann has devised a simple method of illustrating this point. A funnel of white cardboard is illuminated inside by a glow lamp and vertically up the axis of the funnel is fixed a glass rod. Looking through a slit in the side of the funnel the rod is invisible until it or the lamp is shifted to one side of the axis of the funnel. A transparent object immersed in a fluid of the same refractive index is invisible; for instance, the end of a glass rod is invisible when dipped in Canada balsam (or, better, in a solution of eight volumes of chloral hydrate in one volume of glycerine) while, when withdrawn, the end appears to melt.

When using interferometers it is often very difficult to obtain sufficient magnification of the bands of light obtained without too great a loss of light. Lord Rayleigh some years ago devised a most ingenious way of getting over this difficulty. He constructed a telescope with a cylindrical lens as an eyepiece and a lens tilted at an angle to the vertical plane as object glass: in this way he obtained a telescope magnifying in only one direction.

It is only possible to compare intensities of light definitely when the light is of the same colour, *i.e.*, of the same wave length. The comparison of differently coloured sources should be made by means of a spectrophotometer—a spectrometer with a Nicol prism which, on rotation, cuts off more or less of the light of any particular wave length. The numerical value of the total intensity of any light source may be obtained from the monochromatic intensities by allotting to each colour a co-efficient, and then summing up the intensities obtained thus for all the colours. M. Thovert has recently worked on these lines and has selected the distinct vision of form as the basis from which to deduce the value of these co-efficients. This method is preferable to that based on obtaining a colour sensibility curve. In the one method a grating spectroscope is used, and a monochromatic ray is isolated by means of a slit, and the luminosity regulated by suitable means; a pattern is placed in the path of the light at the limit of distinct vision, and the wave lengths found for any particular degree of illumination for which the pattern is just visible. The other method is dependent on finding the extreme wave lengths visible when the light from a spectrum is shielded by grey-tinted glass of different depths. There are many problems of great interest in photometry of light of different colours, the subject of colour blindness being intimately connected with it. We must return to the question in another issue.

The measurement of resistance of a mercury column has been employed by T. R. Merton to calibrate capillary tubes, always a troublesome proceeding when done by measuring the change in length of a pellet of mercury. The ends of the capillary tube communicate with two mercury cups which are connected to one arm of a Wheatstone's bridge. The mean radius r is given by $r^2=\frac{l+2dr}{\pi\kappa f}$ where l is the length of the capillary, f the found resistance and d a correction for the stream lines at the ends of the capillary, κ the specific conductivity of mercury. It has occurred to the writer that measurements of volume in gas burettes might be made by inserting an iron resistance wire down the burette inside so that the mercury uncovers more or less of the wire as it is raised or lowered, the change in resistance of the wire being accurately measured.

Professor Theodore Richards has employed a method of electrical contacts for measuring volumes very accurately. As the mercury is lowered so it can be set to just make or break an electrical contact consisting of a fine platinum point. He has used the method to determine differences in the compressibilities of liquids.

Mr. E. H. Rayner has recently described an ingenious arrangement for measuring small thicknesses and displacements with far greater sensitiveness than the micrometer will attain to. It consists of three conical feet, two in one plane and the other half-way between them, but slightly out of the plane, so that they rest in a hole, slot, and plane at the corners of a very obtuse angled triangle. The three feet are affixed at the upper end, to a lever carrying a concave mirror focussing a spot of light into a screen. Any slight shift of the third foot, the one that lies slightly out of the plane, causes a slight rotation of the lever, which is magnified considerably by the spot of light. The author has employed the apparatus to measure the expansion of short bars of quartz, only fifteen centimetres long; also uses are found for it in measuring thicknesses of mica, paper and foil; or, again, as an adjunct to a chemical balance, to obtain a first approximation to the weight. In the latter case the three legs of the tilting table are affixed to the end of three rods fitted at their other ends into a block of metal. The centre rod, on being bent by affixing a weight to it, will then tilt the table proportionally to the weight applied and the position of the weight on the rod.

In Messrs. Paul's recent catalogue there are to be found two instruments of considerable interest which have been designed and placed on the market. The one is a thermoelectric junction and unipivot galvanometer combined with a special compensator patented by Mr. C. R. Darling. This compensator eliminates any error due to the heating of the cold junction. Any change in the temperature of the cold junction

is compensated for by means of a metallic thermometer which twists the spring of the unipivot galvanometer so as to counteract the inaccuracy of the reading due to this change of temperature of the cold junction. Thus the instrument can be employed without any corrections to read conveniently any temperature, being specially adaptable to the measurement of low temperature, *e.g.*, refrigerators, and so on.

The other instrument, the "Ampall" we must leave till next month to describe.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

BIOLOGY OF A HAY INFUSION.—Everyone knows that a "hay infusion" becomes a little world teeming with animal and plant life, and that it goes through a cycle of changes, form after form rising into dominance and then disappearing. Professor L. L. Woodruff, who has made so many interesting studies on *Paramoecium*, has begun a series of precise studies on the biology of the hay-infusion, by devoting himself particularly to what happens in the case of this infusorian. "The interdependence of the organisms of a hay infusion is so complex that, taken as a whole, it is almost beyond the possibility of analysis, and accordingly the logical method of approach to the subject is to study the interaction of isolated organisms and small groups of organisms on themselves and on each other." His first question was: "How is *Paramoecium* affected by different volumes of the culture medium?" and his answer is that the greater the volume the more rapid is the rate of division. He went on to enquire into the effect of changing the culture-medium, and found evidence that *Paramoecium* excretes substances which are toxic to itself when present in its environment. These substances are more effective when the organisms are confined in limited volumes of culture fluid. These poisonous excretion-products play an appreciable part in determining the period of maximum numbers, the rate of decline, and so on, of *Paramoecium* in the "hay-infusions."

AN INTERESTING MARINE HELIOZOON.—Some years ago, Sassaki described a large Heliozoon, *Gymnosphaera albida*, which occurred in the salt water aquarium of the Zoölogical Institute at Munich. It was supposed to have been transported from Rovigno. Maurice Caullery has been fortunate enough to rediscover *Gymnosphaera* on seaweed at Banyuls, and he adds some notes to Sassaki's description. It is a large Protozöon, easily visible to the unaided eye; it has long pseudopodia which sometimes anastomose; and it may have as many as twenty or thirty nuclei. In some cases it armours itself with numerous borrowed spicules of sponge and Holothurian.

LUMINESCENCE OF FIRE-FLIES.—Notwithstanding numerous investigations there seems to be still a great deal to be discovered in connection with the luminescence of fire-flies. F. A. McDermott and C. G. Crane have been recently studying some of the American Lampyrids. They find practical identity in the structure of the light-producing organs in these beetles, which are popularly called fire-flies. The organ has two layers, an inner one, white and opaque, which seems to serve as a reflector, and perhaps protects the insect from its own brightness, and an outer one, yellowish and translucent, which is the seat of the actual photogenic process. Physiological work led long ago to the conclusion that the photogenic process was of the nature of an oxidation, and this is corroborated by the study of the structure, *e.g.*, by the demonstration of the innumerable tracheae which penetrate the organ.

RHYTHMS OF ACTIVITY AMONG TERMITES.—It is probable that there is a rhythmic character in animal activities to a greater extent than we as yet realise. Internal rhythms have been established in the course of ages in adaptation to external periodicities. But it does not, of course, follow that there is greater activity during the day. In a termites' nest, for instance, Andrews and Middleton have shown that there is about five times as much a-doing, as expressed by the traffic in the arcades, in the greatest bustle of night work as in the greatest ebb of noon. With great patience they counted the comings in and goings out. "In one case the number of termites going into the nest each hour varied from 1,702 between 1 and 2 p.m. to 8,100 between 2 and 3 a.m., while in the same case the numbers going out of the nest were 1,194 between 12 and 1 noon, and 6,820 between 1 and 2 a.m." The curves show that the termites work at all hours of day and night. Yet there are distinct rhythms in the activities of the entire community.

DISSEMINATION OF DISEASE BY HOUSE-FLIES.—The part that is played by flies in disseminating tropical diseases is well known, and our house-fly is a typhoid distributor. In regard to another common fly, the Biting Fly (*Stomoxys calcitrans*), it has been recently proved by Prof. A. Schuberg and Dr. Ph. Kuhn that if it is itself artificially infected with deadly Trypanosomes and Spirochaets, it can transfer these to higher animals.

SYMBIOTIC MICRO-ORGANISMS IN A CATERPILLAR.—In many animals there are minute inmates of the food-canal which have a useful action on the food. There are, for instance, some beautiful Infusorians which seem to be always present in the horse's intestine, helping in the breaking down of the hay and other food-stuffs. Some other animals are known to have a friendly contingent of intestinal bacteria. P. Portier has been working lately at the interesting caterpillar of *Nonagria typhae*, which feeds inside the stem of bulrushes. The digestive area is very restricted, and no ferment able to digest cellulose could be found. But there was great abundance of minute "pseudo-bacteria", probably small moulds, which work at the vegetable tissue, breaking it down. They pass through the wall of the intestine and are engulfed by the caterpillar's amoeboid blood corpuscles. The case requiries further investigation, but it looks like a genuine partnership, as if the "pseudo-bacteria" were middle-men between the animal and its food.

MOUNTING MINUTE ARTHROPODS.—In spite of many recipes it is often difficult to make a satisfactory business of mounting minute Arthropods, such as small Diptera, Hemiptera, and Acarines. Maurice Langeron recommends very strongly the following method. He kills the specimens in hot alcohol, and after a few minutes transfers them to "chloralphenol," either in a large drop on a slide or in a little tube. This secures clearing and dehydration, and the specimens can be transferred directly to balsam dissolved in xylol. The fluid that works so well is Amann's chloralphenol. It may be prepared by mixing two parts of hydrate of chloral with one part of phenol, or by mixing equal parts of para-monochlorophenol and hydrate of chloral. The mixtures are liquefied at a gentle heat.

INCUBATION OF CYCLAS EMBRYOS.—It is well-known that these develop in the shelter of the inner gill-plate. The incubatory sacs have been recently studied in detail by Poyarkoff, who brings out the interesting point that they are in the main due to leucocytes. In other words, they arise by a process analogous to inflammation and the gill-lamella requires some patching afterwards, especially as regards its ectodermic epithelium.

QUERIES.

44. COLOURS OF THE SPECTRUM.—Can the green part of a spectrum be divided into yellow and blue? If so, how is it that the prism does not cause the yellow to fall within the yellow limits, and the blue within the blue limits, leaving the green position blank? If not, can every colour of a definite wave length be called a "Primary colour"?
H. T.

45. HEAT AND A VACUUM.—If heat can travel over a vacuum, how is it that a vacuum flask prevents a liquid from cooling?
H. T.

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46. GLOBE LIGHTNING.—I stated recently in conversation as a positive fact the existence of the phenomenon called "Globe Lightning," and described as a luminous ball which moves slowly and finally explodes with violence. The assertion was warranted by text-books of Meteorology, published not very long ago, but in the new edition of the "Encyclopaedia Britannica" I can find no reference to the subject.

Can you or any of your readers kindly inform me whether the phenomenon is now discredited and must take its place, with "the all-dreaded thunder-stone," among the myths of popular science? A. D. W

REVIEWS.

BOTANY.

An Introduction to Vegetable Physiology. By J. REYNOLDS GREEN. 470 pages. 182 illustrations. 9-in.×5¾-in.

(J. & A. Churchill. Price 10/6 net.)

Professor Reynolds Green's book on Physiology first appeared some ten years ago, and the third edition which has now been brought out has been altered considerably in the light of the experience gained in the interval, while the progress of science has rendered it necessary to re-write certain sections. The chapter on the differentiation of plant body has been expanded and, generally speaking, the author has set himself throughout to combat an idea which has arisen during the last few years that many alterations may go on in protoplasm "without involving any interchange with its substance."

CHEMISTRY.

Science and the Criminal.—By C. AINSWORTH MITCHELL. 240 pages. Illustrated. 7½-in.×5-in.

(Sir Isaac Pitman & Sons. Price 6/- net.)

Readers of "KNOWLEDGE" have long been familiar with Mr. Ainsworth Mitchell's writing, and know that he is an expert on the subjects of inks and the age of handwriting. They will therefore be prepared to find that Mr. Mitchell has produced a very interesting and readable volume, not only in the directions indicated, but on the whole question of the relationship of science to the criminal.

In his introduction he cites a case where the whole of the chemical and medical evidence in connection with a poisoning trial was, on the advice of the judge, submitted to an independent scientific authority, with the result that six reasons were given pointing to the guilt of the accused, while eight were in the opposite direction. Mr. Mitchell claims that there is abundant justification for the plea that the poor prisoner should have the same advantages as regards scientific assistance as he now possesses in legal matters, and thus be placed on an equality with the wealthy prisoner. He further adds that it ought not to be a difficult matter to draw up a list of men of recognised standing in chemistry and medicine who would be willing to serve in this capacity when selected by the judge in a trial.

The first part of the book deals with methods of detection, capture and identification, and shows how science makes it increasingly difficult for the guilty to escape. Interesting details are given concerning trials in which scientific evidence has proved of importance, and a chapter deals with identification of human blood and human hair, which will prove of interest to the biologist. The book, however, as a whole, cannot fail to be attractive both to the scientific and to the general reader.

The Mechanism of Life.—By DR. STÉPHANE LEDUC. 172 pages. 64 illustrations. 9-in.×6-in.

(Rebman Limited. Price 6/- net.)

We have already reviewed Professor Leduc's "Théorie Physico-Chimique de la Vie et Générations Spontanées," of which the present volume is an English Translation made by Mr. Deane Butcher, and revised and corrected, as well as in many places re-written, by the author himself. Mr. Deane Butcher has from the beginning taken the very greatest interest in Osmotic growths, which he has experimented with himself, and of them he says there is no more wonderful and illuminating spectacle. "A crude lump of brute inanimate matter germinating before our eyes, putting forth bud and stem and root and branch and leaf and fruit, with no stimulus from germ or seed, without even the presence of organic matter. For these mineral growths are not mere crystallizations, as many suppose; they increase by intussusception and not by accretion. They exhibit the phenomena of circulation and respiration, and a crude sort of reproduction by budding; they have a period of vigorous youthful growth, of old age, of death, and of decay." We congratulate Mr. Deane Butcher on his successful attempt to put the question before the British scientific public.

ENTOMOLOGY.

The Lore of the Honey Bee.—By TICKNER EDWARDS. 72 pages. 1 illustration. 7-in.×4¼-in.

(Methuen & Company. Price 1/- net.)

To those who are interested in Natural History generally, or in Bees in particular, this little volume will prove most attractive. Although it contains much solid information it is yet written in a way that encourages one to read on, and it is historical as well as biological and apicultural.

Our Insect Friends and Foes.—By F. MARTIN DUNCAN. 296 pages, 16 plates. 7¾-in.×5-in.

(Methuen & Company. Price 6/-.)

The facts of natural history never become dull, and though writer after writer brings them before us and even chooses the same themes, they never become tiring. For each naturalist puts them before us in his own way, dwelling on something which has not been emphasised before, adding sometimes to the store of knowledge and, may be, putting a new interpretation upon old and familiar observations. Mr. Martin Duncan is well known to many as a lecturer who puts before others the things which interest him in a quiet but effective and convincing way. In dealing with the subject of insects (in connection with which he has done much work), whether it be the useful burying bettles, mimicking butterflies, the forms which are of value in commerce, or dangerous by transmitting diseases, he is always lucid, accurate and entertaining.

GEOLOGY.

Geology for Engineers.—By LIEUT.-COL. R. F. SORSBIE, R.E. 423 pages. 94 illustrations. 8-in. × 5¼-in.

(Charles Griffin & Co. Price 10/6 net.)

This is an ill-balanced book. The first part, dealing with theoretical geology, is a thorough and painstaking compilation from authorities, many of which, as can be seen from the list of works consulted, are antiquated and now only of historical value. Consequently, this part contains many curious slips which would have been avoided had the author kept his knowledge of the science up-to-date. The second part treats of the practical application of geology to various engineering problems, such as water supply, building materials, roads, canals, rivers, and coast-erosion. In this the author is evidently at home, and has produced a practical manual of the utmost value to engineers, who have too often to regret their small amount of geological training. This part is indeed so good that it is a matter for regret it was not expanded so as to fill the entire volume. The need for which the first part

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was written could have been met by a reference to modern elementary text-books, or by a recommendation to the student-reader to take a class in elementary geology. Misprints are commendably few, although we read "rainful" for "rainfall" on page 240. A full and accurate index is provided.

G. W. T.

The Student's Lyell.—By E. JOHN W. JUDD, F.R.S. 645 pages. 736 illustrations. 8-in.×5¼-in.

(John Murray. Price 7/6 net.)

We welcome the appearance of the second edition of "The Student's Lyell" edited by Professor Judd, which the latter has corrected and endeavoured to bring up-to-date. In Professor Judd's words: "Now that the doctrine of Evolution—as applying alike to the Inorganic and the Organic world—is universally accepted, the writings of Lyell, who was truly 'the Forerunner of Darwin,' acquire a new interest and are invested with a permanent value. The 'Origin of Species' has been justly asserted by Huxley to be 'the logical sequence to the "Principles of Geology"'; it has therefore seemed fitting to prefix to a new edition of the present volume a history of the events which led up to the production of Lyell's epoch-making work."

The Geology of Building Stones.—By J. ALLEN HOWE, B.Sc., F.G.S. 455 pages. 46 illustrations. 7½-in.×5-in.

(Edward Arnold. Price 7/6 net.)

This is the fourth volume of Arnold's Geological Series, and, like the preceding ones, deals with a particular aspect of economic geology, the growing importance of which is urged in the breezy introductory chapter to this work. A brief survey of the rock-forming minerals is first given. An account of igneous rocks, sandstones, grits, limestones and slates follows, in which, while the purely scientific side is not forgotten, emphasis is placed on the various practical aspects appealing to the architect and engineer. Notes on the distribution of the various types are given, and, naturally, most space is allotted to rocks occurring in the British Isles. Much useful information, hitherto hard to get, is contained in the chapter on the decay of building stones. The book closes with an excellent section on the testing of building stones, giving a resumé of all known methods, and estimating their comparative values. This is a most valuable part of the book, for, as the author says, architects are deterred, by the fear of risk, from using many good stones with which they are unfamiliar, because no reliable tests have been made of these materials. Some appendices contain lists of quarries, and a bibliography. A very full index is given. The book is illustrated with several good plates and informative maps, and will be invaluable to the architect or engineer who cares to apply its scientific principles to practice.

G. W. T.

MATHEMATICS.

A New Trigonometry for Schools and Colleges.—By the Rev. J. B. LOCK, M.A., and J. M. CHILD, B.A., B.Sc. 488 pages. 180 illustrations. 8-in.×5½-in.

(Macmillan & Co. Price 6/-.)

In opening a book bearing the names of two experienced authors, we expected to find much that was sensible and practically useful. In this we were not disappointed; but a surprise was in store for us in the arrangement of the subject matter and also in some of the matter itself. This is a very "live" book, and a student of fair ability will probably acquire from it a sound working knowledge of Trigonometry up to and including de Moivre and Infinite Series and Products with very little waste of time. In particular we may call attention to the admirable diagrams, the descriptions of instruments, the model solutions of triangles with the aid of logarithms, the proofs and figures for general formulae, the treatment of interpolation, and errors of observation. In the preface, attention is drawn to the fulness of the answers, in which hints for solutions of the harder questions are given, as there is no intention of issuing a key. One of these hints is "Use Ptolemy's Theorem." Ptolemy is not in the index, but we ran him to ground on page 383, being familiar with his haunts. Little omissions of this kind disappear in a second edition. We cordially commend the book to the attention of all teachers of mathematics.

MICROSCOPY.

Practical Photo-micrography.—By J. E. BARNARD. 322 pages. 10 plates and 79 figures. 8¾-in.×5¾-in.

(Edward Arnold. Price 15/- net.)

The usefulness of the microscope and the advantages of photography being so great and so well recognised, it follows that photo-micrography must be equally important. The thanks, therefore, of all those who are about to take up the work are due to Mr. Barnard for affording them an opportunity of obtaining an insight into the subject, before beginning operations, while those who have had to gain their experience for themselves cannot fail to find some points of interest in "Practical Photo-micrography." The book fulfils the promise of its title; for all the information is given clearly, and in such a way that the directions and advice can easily be followed. The microscope is briefly considered, then two chapters are given up to the optical equipment necessary, while an account of sources of illumination, and descriptions of the various photo-micrographic cameras are followed by hints as to the use and manipulation of a microscope, and after the more purely photographic part of the subject has been considered, some very useful appendices are added. In his introduction, Mr. Barnard most properly advises a microscopist who is anxious to start the work, to acquaint himself thoroughly with the processes of ordinary photography; while, similarly, he urges the photographer to master the general technicalities of ordinary microscopic work. The book under consideration should always be at the elbow of every worker with the microscope.

TIDES.

Moxly's Theory of the Tides.—By J. F. RUTHVEN. 103 pages. 18 illustrations. 9½-in.×6-in.

(J. D. Potter. Price 2/-.)

Lieut. Ruthven worked with the late Rev. J. H. S. Moxly in perfecting the theory which the latter put forward with regard to the tides. The present book is a reprint of four chapters dealing with the subject, to which have been added several new ones and a number of quotations from Mr. Moxly's book which he did not live to rewrite. In the preface Lieut. Ruthven points out that in the theory there was an error due to accepting the assumption of the dynamical theorists that the only way that the tangential component of tidal force could work was by means of surface currents. Closer examination convinced Moxly and Ruthven that it, like the normal component, produced pressure.

TOPOGRAPHY.

The Evolution of Kingston-upon-Hull.—By T. SHEPPARD. 203 pages. 29 illustrations. 9-in.×5¾-in.

(A. Brown & Sons. Price 3/6 net.)

At the request of the Museums and Records Committee of the Hull Corporation, Mr. Thomas Sheppard has elaborated a presidential address of his to the Hull Literary Club, and has shown by means of plans, dating from the sixth century to the present time, the way in which the city of Hull has gradually come into being. He describes no less than three hundred and ninety-seven plans, twenty-nine of which are reproduced to form illustrations. The book should prove most useful for reference to those interested in the history of Hull. The remarkable feature of a plan made in the time of Elizabeth, but evidently copied from one of much earlier date (probably the middle of the fourteenth century) is the large amount of space within the city walls which was devoted to gardens. They practically surround the buildings on all but one side.

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THE BRITISH MUSEUM (NATURAL HISTORY).

THE tide of opinion against the erection of a new science museum between the Imperial College and the Natural History Museum at South Kensington, continues to gather strength. At present the plot of land bounded on the north by Imperial Institute Road, on the south by Cromwell Road, and lying between Queen's Gate and Exhibition Road, is occupied by the two great institutions just mentioned. At the back of the Natural History Museum is the Spirit Building, between it and the Imperial College are the temporary buildings of the Science Museum. The suggestion is that the Spirit Building, which cost £30,000, shall be pulled down, that the ground which it occupies and some on each side of it shall be taken away from the British Museum and form the site of a new science museum.

A glance at the plans issued with the Government white paper, numbered Cd. 5650, will show at once how each of the institutions will hamper the others. There will be absolutely no hope for the Imperial College to spread, the Science Museum will be in the same predicament and the Natural History Museum which long ago ought to have been enlarged will not only lose a part of the land definitely allocated to it, but even the space which is left, if the Government scheme does get carried out, will be encroached upon, because it is proposed to erect a new spirit building along the frontage to Queen's Gate making it for all practical purposes under ground, and bringing the roof four feet above the level of the pavement. The accommodation in the present building is bad enough, but why should it be proposed that those who work at the animals themselves, rather than their stuffed hides, bleached bones, and mummified remains should be condemned to carry on their researches in a subterranean excavation.

It is no wonder that the trustees of the British Museum and lovers of Natural History throughout the British Isles, though quite as anxious as other scientific people that the new museum should be erected, should wish that some other site might be found for it.

In the case of private individuals a bargain would have to be kept, and why should not the Government be expected to fulfil an arrangement definitely made. There are plenty of open spaces on the east side of Exhibition Road and, comparatively speaking, few houses. No doubt it would be some hardship for private individuals to have to part with their dwellings, but surely the development of scientific collections belonging to the nation is as important as the making of a railway by private persons, and it is necessary to look beforehand, not for twenty, but for many hundreds of years.

The original memorial to the President of the Board of Education with regard to the Science Museum was signed by over one hundred scientific men, mostly chemists, physicists and astronomers. Dr. Shipley, Master of Christ's College, Cambridge, has already sent in the names of nearly a thousand eminent men and women, who have signed a memorial expressing their emphatic opinion that nothing should be done which interferes with the development of the Natural History Museum or which limits the scope of the proposed science museum.

The Entomological Society, knowing that the Insect Department of the Natural History Museum greatly needs more space, has also passed a resolution of a similar character; the South London Natural History Society and the South-Eastern Union of Scientific Societies have done the same, as well as the Essex Field Club, and we have received the following resolution which has been still more recently passed at a special Council Meeting of the Selborne Society, which now numbers nearly three thousand members.

"That the Council of the Selborne Society learns with grave concern, the declared intention of the Government to alienate a part of the British Museum (Natural History) in order to form the site of a new museum, and respectfully urges upon the authorities that they should seek another site for the new institution, so that both museums may have room for their due expansion."

NOTICES.

THE NEW FAIRY FLY.—As we go to press Mr. Fred Enock telegraphs to say that he has succeeded in breeding a female of *Mymar regalis*, the male of which he recently discovered, and describes and figures on pages 271 to 273 of the present number of "KNOWLEDGE."

X-RAY APPARATUS.—The Admiralty has ordered from Messrs. Newton and Co., of 3, Fleet Street, London, ten sets of X-Ray apparatus for the new battleships for service afloat, making thirty complete installations that this firm has recently supplied to the Royal Navy.

INTEREST TABLES.—We have received from Messrs. Charles and Edward Layton, Layton's Simple Interest Tables (price 5/- net), by Alexander S. Sellar, which deal with amounts ranging from £1 to £100,000 for intervals of one day up to three hundred and sixty-five days and for intervals of one month up to twelve months.

MICRO-CINEMATOGRAPHY.—Messrs. Pathé Frères have prepared, under the direction of Dr. J. Comandon, of Paris, a series of cinematograph films of microscopic objects for use by lecturers, scientific societies and in schools. At a recent demonstration arranged for "KNOWLEDGE" these films were seen to be of great interest, showing, as they do, the circulation of the blood, Brownian movements of the platelets in the plasma, phagocytosis by the white corpuscles or leucocytes, clearly illustrating the extrusion and retrocession of pseudopodia, and, most interesting of all, living trypanosomes and spirochaetes in the blood of infected animals. The phenomena of agglutination of the spirochaetes in the later stages of relapsing fever and haemolysis of red corpuscles were extremely well displayed.

For more popular purposes films were shown of the life-history of the swallow-tail butterfly, caterpillars feeding on wild carrot plants, their movements and the extrusion of their horn-like scent appendages, pupation, the emergence of the imago, the drying of the wings, and then the beginning of the active life of the perfect insect among the flowers. Another film showed the development of the Axolotyl within the egg, its emergence and, subsequently, its preying on tadpoles. Students who are not aroused to enthusiasm by such exhibitions must indeed be hard to please.

SUMMER FLOWER SHOW AT OLYMPIA.—The Flower Shows of the Royal Horticultural Society are famous throughout the world for their excellence and beauty, and they well deserve the popularity which they enjoy. The Society fosters, and by its Exhibitions nourishes, the love of plant life in the hearts of English people, and its direction is sought by an ever-growing body of people representing all classes of Society. The increase in the number of Fellows, and the crowds attending the Flower Shows, are putting a great strain on the Council and Officials, who are doing all that is possible to do to meet the demands of the times in horticulture. Therefore, friends of the Society welcomed the proposal that the Summer Show of this important year should be on a scale of magnificence and comfort hitherto wholly unprecedented in the Society's history, and the great Hall, "Olympia," was accordingly engaged for it. The dates fixed are July 4th, 5th and 6th. Many exhibits will, in themselves, be quite considerable gardens. Summer being at its height, the exhibits will largely comprise open-air trees and plants, rock-gardens and water-gardens.

On July 4th the Show will be open from 12 noon to 10 p.m.; on July 5th from 9 a.m. to 10 p.m.; and on the 6th from 9 a.m. to 6 p.m. In order that the public with narrow purses and little spare time may take advantage of the opportunity thus offered, the price of admission after 6 o'clock on the first two days is to be one shilling.

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